DOCUMENT RESUME

ED 325 707 CE 056 295

TITLE	Missouri Introduction to Energy and Power Technology Guide.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE	90
NOTE	618p.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (Order No. 60-1100-I: $44.25, including disk).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052) -- Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF03 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Behavioral Objectives; Competency Based Education; Electricity; Electronics; *Energy; High Schools; Industrial Arts; *Industry; Learning Activities; Learning Modules; *Power Technology; State Curriculum Guides; Teaching Guides; *Technology; *Trade and Industrial Education
IDENTIFIERS	Missouri

ABSTRACT

This guide provides materials for the first high school specialization course beyond the broad-based foundation provided by the Introduction to Industrial Technology and Exploration of Technology courses. Section I is the Instructor's Guide, which contains suggestions about how the energy and power technology cluster might be taught as a course for grades 9 through 11. Nine units are suggested and each is detailed separately. Each unit consists of a unit title, set of competencies, content outline, teacher plans and activities, suggested student activities, and resources and references. Topics include: overview; technological procedures; energy fundamentals; power fundamentals; control and instrumentation fundamentals; applications; electricity/electronics technology applications; careers; and leadership. Section II contains 20 Technology Activity Modules, a set of representative activities that may be used to address each major unit's goals. Each module contains instructor suggestions and student instructions. Section III, the resource section, contains a detailed list of resources, including curriculum guides, textbooks, and references; a sample set of useful periodicals, publisher, media sources, resource centers, and suppliers; a directory for locating public domain software; and a list of associations/organizations. (YLB)

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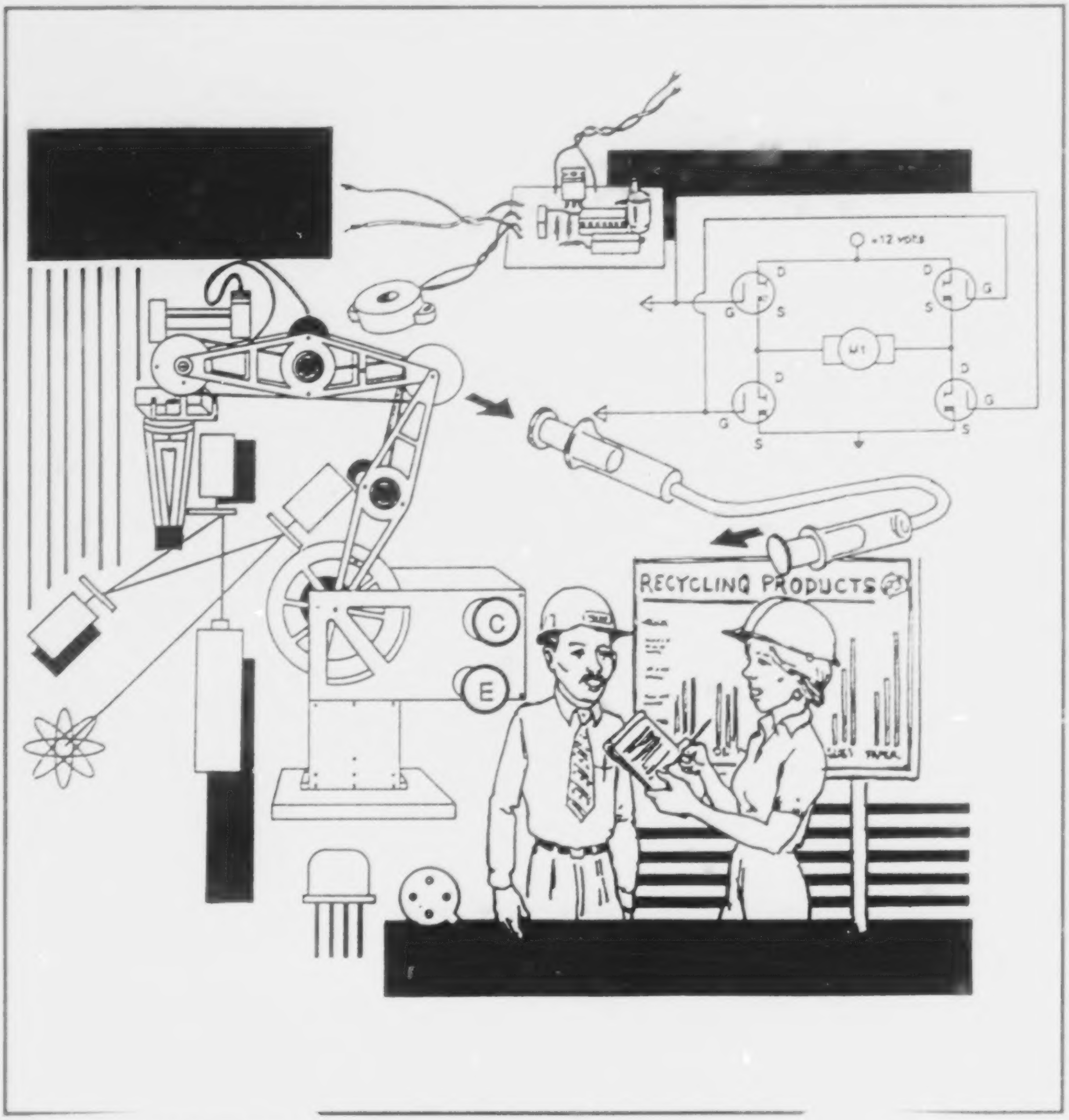
Missouri

Introduction to Energy and Power Technology Guide



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A project funded by the
Missouri Department of Elementary and Secondary Education
Division of Vocational and Adult Education

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

Missouri

Introduction to Energy & Power Technology Guide

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1990

Foreword

This guide is dedicated to the improvement of Industrial Technology Education in Missouri and to all of the dedicated instructors who work hard at this challenge each day! As such, this guide:

- is intended to be the Missouri Industrial Technology Education teacher's primary resource for planning, implementing and instructing energy and power technology courses,

- is further intended to provide Industrial Technology Education students with guidelines for learning about key technological activities relevant to energy and power technology, and

- is also designed to help direct Industrial Technology educators and students to references where they can find additional information about energy and power technology.

How can this guide help me?

If you want to:

1 Learn about this guide

2 Plan major instructional units for Energy & Power Technology

Unit 1. Energy & Power Technology Overview
Unit 2. Technological Procedures
Unit 3. Energy Fundamentals: Forms & Conversions
Unit 4. Power Fundamentals: Transfer & Utilization
Unit 5. Control & Instrumentation Fundamentals
Unit 6. Energy & Power Technology Applications
Unit 7. Electricity/Electronics Technology Applications
Unit 8. Careers in Energy & Power Technology
Unit 9. Leadership Roles in Technology

3 Teach E&P Technology Activities

TAM 1. Energy & Power Odyssey - Applications for the Future
TAM 2. Adventures With Systems Theory
TAM 3. Designing and Conducting Experiments
TAM 4. Technology Assessment Process
TAM 5. Energy Conversions
TAM 6. Physics Revealed/Made Useful
TAM 7. Adventures in Flight
TAM 8. Internal Combustion: Energy Converters
TAM 9. Fundamentals of Fluid Power
TAM 10. Fundamentals of Mechanical Power Transmission
TAM 11. Electric Motor Control - Robotics
TAM 12. Instrumentation and Control Revealed
TAM 13. Energy Audits
TAM 14. Superconductivity: Speeding into the Future
TAM 15. Making Lasers Work for UsElectrical Distribution Model
TAM 16. Electrical Distribution Model
TAM 17. Applying Electric Motors
TAM 18. Using Electric Instrumentation
TAM 19. Getting The Job/Scholarship You Want
TAM 20. Today's Leaders for Tomorrow

4 Identify useful resources

Acknowledgements

This Introduction to Energy and Power Technology Guide is specifically designed to be useful to Missouri's Industrial Technology education teachers. It builds on, and is consistent with, the foundation established by the Missouri Industrial Technology Education Guide, and the junior high/middle school guides for ITE (Introduction to Industrial Technology Education, Exploration of Industrial Technology Education). In addition, however, this document, by focussing specifically on materials and processing technology, represents the final high-school-level curriculum guide needed to complete Missouri's redirection of its entire ITE program.

This guide could not have been developed without the generous assistance of many individuals and groups. Clearly, the members of the project's advisory committee, as named on the frontispiece and in the TAMs they authored, are prime examples of such dedication. In many ways, this Guide is more a product of their insights than those of the project staff.

Similarly, the members of the project's fieldtest team made significant contributions by helping insure that the Guide's contents were, above all, feasible for implementation in Missouri's varied school settings.

The Guide also includes much of the good practice fostered by Missouri's university and college teacher educators. Therefore, appreciation is extended to my present and former colleagues, at UMC and at each of the other state institutions, for their willingness to share their work. Of these faculty, my colleague and project coordinator, Rodney Custer, must be singled out and specially acknowledged for his insightful contributions, his attention to detail, and his exemplary conquering of this project's numerous challenges.

The project team also wishes to acknowledge the cooperation and contributions of many colleagues in other states. After all, this Guide represents a compilation of the best thinking of the profession, regardless of where it is found. As such, input from Arizona, Georgia, Illinois, Iowa, Kansas, Nebraska, New Jersey, North Dakota, Texas, Utah, Virginia, West Virginia and Wisconsin publications and supervisors made significant contributions, which we certainly appreciate.

Stephen Coffman, the state's Industrial Technology (Industrial Arts) Education supervisor, deserves special acknowledgement and credit for this Guide. His initiative in conceptualizing and funding a long range and continuing plan for the state's development of a consistent series of industrial technology education guides made possible Missouri's bold step into the technological future. Similarly Linda Heck's and Yusuf Al-Hassan's dedicated work, insightful writing, and constructive interaction made essential contributions to the overall success of the Guide. Also making a significant contribution, was the art team lead by Dan Stapleton. Dr. Phyllis Miller, the project's administrative co-director, did much to make the project feasible through her careful attention to detail and project facilitation.

Special recognition must also be extended to Denise Aholt and Shannon Monnig. Without their enthusiastic contributions to the project's operation and their tireless work in entering and word processing countless revisions, this Guide simply would not have reached print.

To all of the above, and to the many others unnamed because of space limitations, the project director, on behalf of Missouri's Industrial Technology Education profession, appreciatively acknowledges his debt.

Michael J. Dyrenfurth
June 1990

How To Use This Guide

This guide consists of three sections in addition to these prefatory remarks. Section I is the Instructor's Guide, Section II contains a sample set of Technology Activity Modules and Section III lists key resources and other helpful materials.

Section I -- the Instructor's Guide contains:

- Competencies for each of the nine major instructional units
- Instructional plans for each unit
- Content outlines for each unit
- Teacher and student activities for each unit
- Sample resources for each major unit

Section II -- the Technology Activity Modules contain:

- A set of representative activities that may be used to address each major unit's goals
- Instructor suggestions for each TAM
- Student instructions for each TAM

Section III -- the Resource Section contains:

- A detailed list of resources; that is, curriculum guides, textbooks, and related references; useful to instructors and students
- A summary list of useful periodicals, publishers, media sources, resource centers, suppliers and associations

Time Frame for Instructional Delivery

The instructional units outlined in this guide may be used for courses of varying length. The duration of such courses might range from a minimum of one quarter to a maximum of one year (two semesters). Instructors are encouraged to carefully consider the emphasis placed on each unit to insure that at least some content from each is covered in every course. Units may be shortened by reducing the amount of activity and/or presentation time or by reducing the number of competencies actually addressed. Units may be lengthened by increasing activity time and/or by increasing the depth of treatment for key topics.

Context for Introduction to Energy and Power Technology within Industrial Technology Education

The Introduction to Energy and Power Technology Guide is intended to support the first high school specialization course beyond the broad-based foundation established by the Introduction to Industrial Technology and Exploration of Industrial Technology courses. As such, it is designed to build upon this previous work and to guide students to the mastery of higher level cometencies.

Scope and Approach Employed

This guide is intended to provide more input than can probably be incorporated into any single course. Therefore the ITE instructor is well advised to select key portions to be incorporated within his/her ongoing instruction. In addition, instructors should note that the Technology Activity Modules (TAMS), the suggested instructor and student activities and the resources listed represent but a portion of those that could be listed.

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Unit 4. Power Fundamentals: Transfer & Utilization .... 4: 1 - 4
Unit 5. Control & Instrumentation Fundamentals .... 5: 1 - 3
Unit 6. Energy & Power Technology Applications .... 6: 1 - 6
Unit 7. Electricity/Electronics Technology Applications .... 7: 1 - 5
Unit 8. Careers in Energy & Power Technology .... 8: 1 - 3
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Section II: Technology Activity Modules ---------- TAMs 1 - 20

		TAM #	Pages Instructor Component	Pages Student Component
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TAM 2.	Adventures With Systems Theory	2:	1 - 8	1 - 11
TAM 3.	Designing and Conducting Experiments	3:	1 - 7	1 - 11
TAM 4.	Technology Assessment Process	4:	1 - 8	1 - 8
TAM 5.	Energy Conversions	5:	1 - 10	1 - 17
TAM 6.	Physics Revealed/Made Useful	6:	1 - 7	1 - 11
TAM 7.	Adventures in Flight	7:	1 - 10	1 - 14
TAM 8.	Internal Combustion: Energy Converters	8:	1 - 10	1 - 20
TAM 9.	Fundamentals of Fluid Power	9:	1 - 7	1 - 16
TAM 10.	Fundamentals of Mechanical Power Transmission	10:	1 - 8	1 - 13
TAM 11.	Electric Motor Control - Robotics	11:	1 - 11	1 - 21
TAM 12.	Instrumentation and Control Revealed	12:	1 - 8	1 - 9
TAM 13.	Energy Audits	13:	1 - 8	1 - 22
TAM 14.	Superconductivity: Speeding into the Future	14:	1 - 8	1 - 10
TAM 15.	Making Lasers Work for Us	15:	1 - 10	1 - 15
TAM 16:	Electrical Distribution Model	16:	1 - 9	1 - 15
TAM 17:	Applying Electric Motors	17:	1 - 10	1 - 14
TAM 18:	Using Electric Instrumentation	18:	1 - 9	1 - 12
TAM 19:	Getting The Job/Scholarship You Want	19:	1 - 7	1 - 16
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Missouri

Introduction to Energy and Power Technology Guide

Section I: Instructor Guides

This section contains suggestions about how the energy and power technology cluster might be taught as a course for grades nine through eleven. Nine units are suggested and each is detailed separately.

Each unit in this guide has a cover page with a graphic that highlights the unit's content and that places it in context with the other units in this course. Each major instructional unit in this Introduction to Energy and Power Technology Guide contains a sample set of competencies (coded to the content outline) that describe what students should be able to do when they complete the unit. However, note that the guide is intended to be representative rather than exhaustive. This means that it does not pretend to include all that could be taught pertaining to energy and power technology. **The information and activities contained here are intended to provide the ITE instructor choices from which to make content selections and develop a manageable course**.

Four columns are used to present useful information about each unit. The Content column presents a structural outline of the unit's key concepts and information. The Teacher Plans & Activities column describes some typical activities that instructors can do to help students achieve the desired competencies. The Student Activities column suggests things students might do as part of their work during the unit. Finally, the Resources & References column lists a sampling of important resources that support the unit. This column provides suggestions for support and/or reference materials that may be useful to the topics and activities listed on the left side of the page. Some addresses will be noted here, but most of them are detailed in various parts of section III, e.g., resources, publishers, media suppliers, resource centers, and suppliers. Note that entries in this column direct the reader to specific parts of Section III where address and contact information is provided.

Each unit also includes a graphic that suggests one way of arranging the lessons used to teach the unit. Contained in these graphics are several codes. Rectangles are used to indicate key lesson topics. When several white rectangles are shown within a larger gray rectangle, topics could be combined into a single lesson. This is suggested whenever time constraints require a more cursory treatment of the unit's content to that of related technology courses in ITE's scope. Ellipses indicate topics that bridge energy and power technology to other industrial technology clusters and/or other school subjects such as science and mathematics.

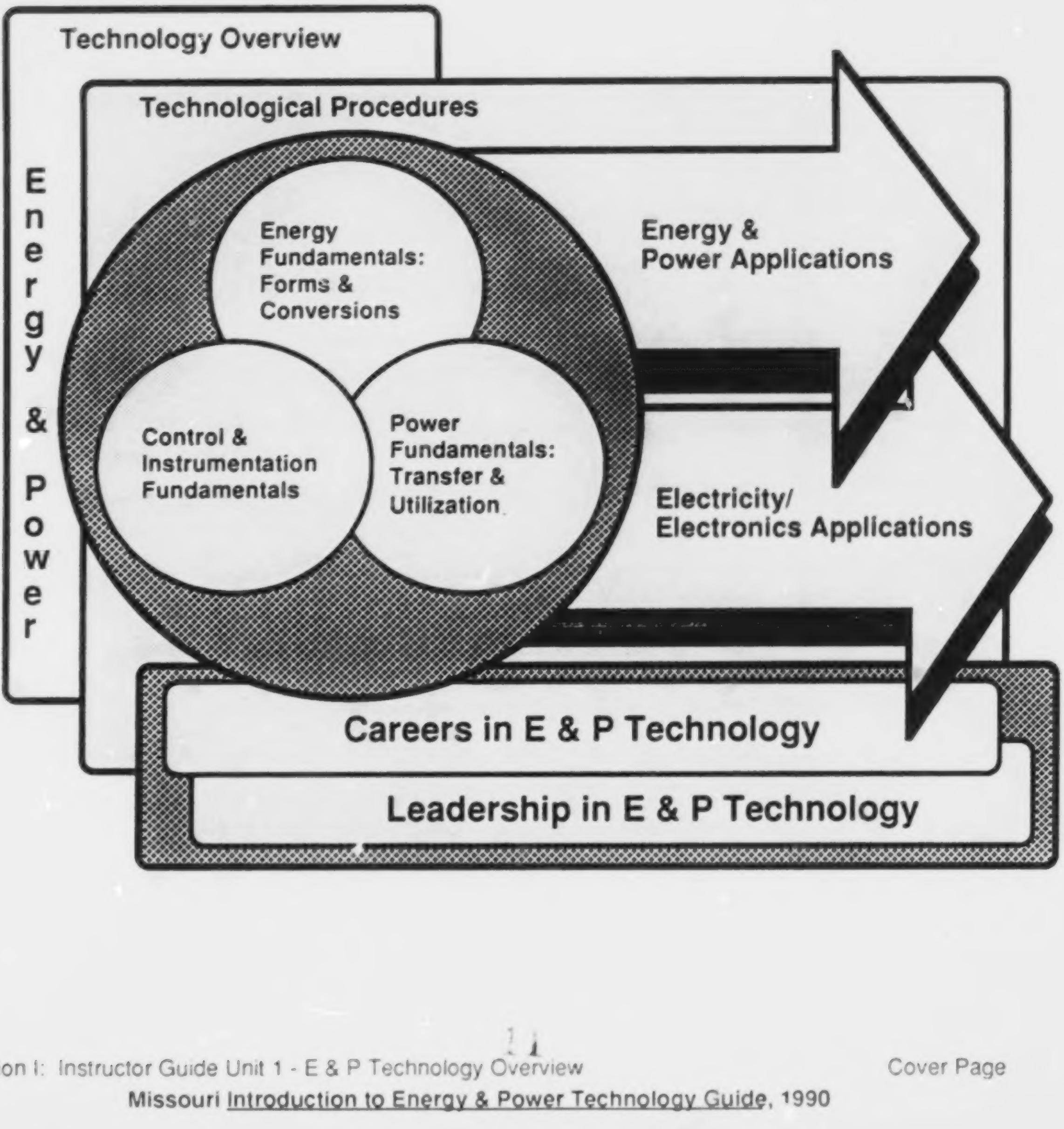
The course is organized into nine separate units. Activities in one unit can be used effectively in other units as well. Some units, e.g., the one about leadership, could be taught as a distributed unit instead of as a freestanding one. Such decisions, of course, are the individual instructor's to make.

Missouri

Introduction to Energy and Power Technology

Instructor Guide

Unit 1: Energy & Power Technology Overview


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

11

Unit One: Energy & Power Technology Overview

OBJECTIVES: The purpose of this unit is to provide a comprehensive introduction to Energy and Power technology. This unit is designed to provide a broad framework for the content for successive units.

COMPETENCIES -- The student will be able to:

1. Describe and illustrate examples of the major types of energy conversion systems, their components and key variables. (1,I)
2. Describe and illustrate examples of power systems, their components and key variables. (1,I)
3. Describe and illustrate examples of instrumentation & control systems, their components and key variables. (1,I)
4. Define and explain the technical terms and concepts used to describe the principles, mechanisms, and systems associated with energy, power, instrumentation & control and electricity/electronics technology and their applications such as transportation systems. (1,I)
5. Define and explain the technical terms and concepts used to describe the principles, mechanisms, and systems associated with selected applications of energy & power technology such as transportation systems. (1,II)
6. Apply hand, mechanized, and automated processes of energy, power, instrumentation & control and electricity/electronics technology through exploratory experiences and laboratory activities. (1,II)
7. Identify and illustrate the components of energy & power technology. (1,II)
8. Trace the historical development of major energy & power systems. (1,III)
9. Describe the interface between energy & power technology and communication technology. (1,IV)
10. Describe the interface between energy & power technology and materials & processing technology. (1,V)
11. Provide examples of the positive and negative impacts energy & power technology has on society in economic, environmental, psychological and sociological terms. (1,VI)
12. Demonstrate the safe and proper use of energy & power technology tools, equipment, materials and processes. (1,VII)
13. Apply the basic scientific foundations of chemistry, physics and mathematics to explain the operation of key energy & power technology processes. (1,VIII)
14. Explain the chemistry involved in key energy conversion processes such as combustion. (1,VIII)
15. Use the physical principles of simple machines to explain the operation of power transmission systems. (1,VIII)
16. Perform calculations and conversion operations using basic mathematical functions. (1,VIII)
17. Employ exponents to facilitate mathematical calculations. (1,VIII)

*[notations in parentheses identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Energy & Power Systems
   A. Energy Conversion Systems
   B. Power Transmission Systems
   C. Manufacturing & Construction Systems
   D. Communication Systems
   E. Transportation Systems
   F. Control & Instrumentation Systems

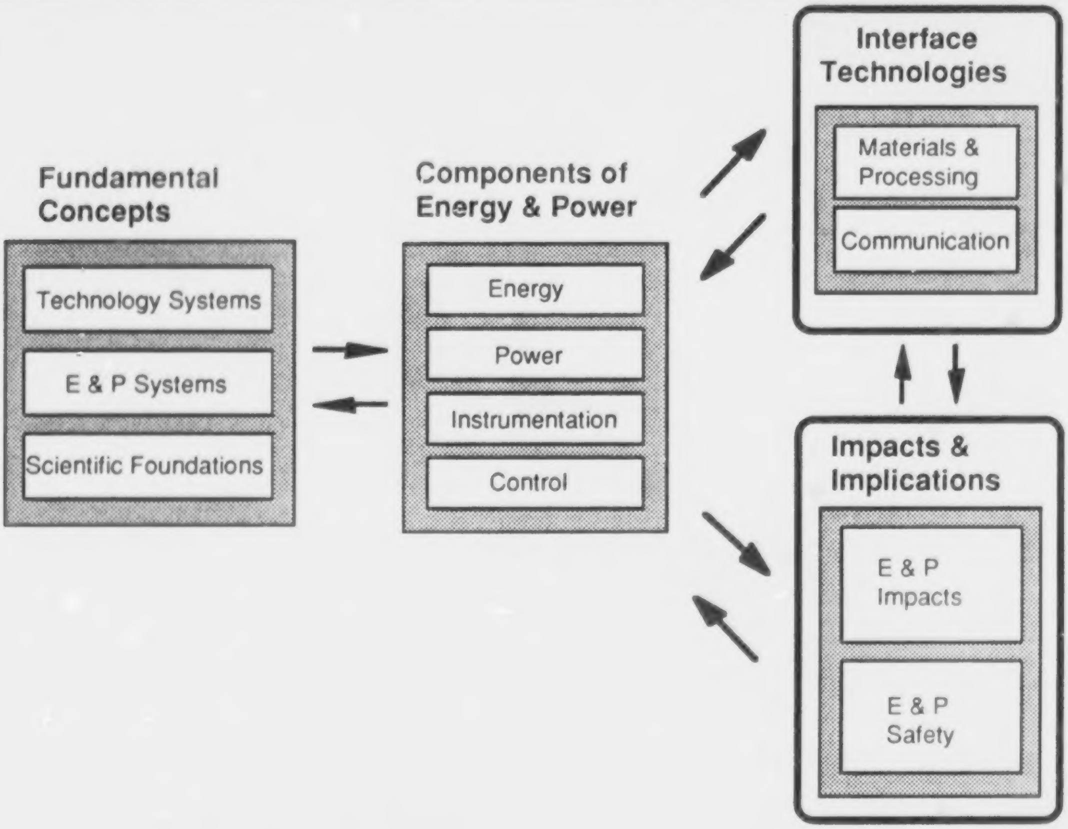
Teacher Plans & Activities

- Arrange a field trip to a power plant.

- Assign a small group activity of conducting a "technology search" where students are to research different types of systems. Have groups present to the class. After completion, have students discuss the overlap and interrelationship between systems.

- Select an E&P related example system as an object for discussion. Possibilities include an automobile, the school's heating system, the school's transportation system, cafeteria food services, etc. Lead a discussion of what constitutes a system. What is a system? How is a system different from a collection of components? How do components function within systems? Is knowledge of components necessary for systems understandings?

Lesson/Activity Outline


Interface Technologies
Materials & Processing
Communication
Fundamental Concepts
Technology Systems
E & P Systems
Scientific Foundations
Components of Energy & Power
Energy
Power
Instrumentation
Control
Impacts & Implications
E & P Impacts
E & P Safety

Student Activities

- Develop a time-li[illegible]owing the evolution of a technology syst[illegible]our choice. Examples could be nuclea[illegible]roelectric power, steam engines, etc. In groups, prepare a time-line display that illustrates the evolution of the system. Students will need to do library research and interviews to collect data.

Resources & References

- AIT Video. Exploring Technology Education. Overview of Energy: Section E-1, MVRC
  [Section III - Part 4, Media Sources]
- YMT Series, MVRC
  [Section III - Part 4, Media Sources]
- Macaulay, D. The way things work.
  [Section III - Part 1, Books & Resources]
- Union Electric Co.
  [Section III - Part 5, Resource Centers]
- National Rural Electric Cooperative Association
  [Section III - Part 7, Associations/ Organizations]
- Society of Manufacturing Engineers
  [Section III - Part 7, Associations/ Organizations]

Content	Teacher Plans & Activities
II. Components of Energy & Power A. Energy B. Power C. Instrumentation D. Control	- Develop a series of slides or transparencies that illustrate the definitions of and differences between energy, power, instrumentation, and control. - Conduct a brainstorming session with students identifying as many examples as possible of the components of energy to make power.
III. Technology Systems A. Systems Model B. Sub-systems & Supra-systems C. Component Systems D. Feedback Systems	- Have the students black box a simple system. Possibilities include: the ignition system of a small engine, a solar collector, a hand held calculator, or a copying machine. Have them break the system down into its components. Encourage students to think through the features that the components would need to work within the system. - Have the students disassemble a simple, unfamiliar system (e.g. a wrist-watch, a telephone, etc.). Have them identify the possible functions of components in the system.
IV. Interface to Communication Technology A. Electronics and Communication B. Light and Communication C. Images and Communication	- Lead a brainstorming session of ways that E&P and communications intersect. - Arrange for students to view a demonstration of a modem, telecommunications, or electronic mail. - Demonstrate the use of a laser in autobody frame alignment. - Acquaint students with the FAX system. - Lead a science fiction type of discussion identifying electronic communication possibilities of the future, e.g. the "beam me up" approach of Star Trek, possibilities for conversations with historical figures through immediate communication transfer from interstellar space, etc.

Student Activities

- Use a world energy simulator program. Explore various energy use scenarios and the predicted effect if things don't change. (Developed at the University of Montana through the U.S. Dept. of Energy. Available through the University of Missouri Extension)
- Construct a model rocket to launch system. Utilize NASA resources and relate to systems model throughout the activity.
- Prepare a list of safety procedures for using model rockets.
- Using the design of a space station as a vehicle, students apply the problem-solving process to handle the energy, power and environmental problems of a space station. A competitive bid situation could be simulated with the students working in teams to "win" the contract. NASA resources are used extensively.
- Prepare a short breakdown of a simple system. Examples could include a stereo system, various systems from your car, a video camera, a heating system, a school system, etc. Identify the components of the system and what each part does. What kind of supra-system is your system a part of?
- Produce a poster display, similar to a science-fair display, explaining a specific concept, process or factor important to energy & power technology. Students are encouraged to relate the concept to the communications and/or materials and processing technologies. The instructor incorporates a competitive aspect in the judging of the posters.
- Working in groups, develop a short skit in which the group will meet with their great-grandfathers. During the meeting they describe what today's world is like, particularly related to communication and energy and power. Include descriptions of items such as electronic telecommunications, satellite communications, cellular telephones, computer networks, and computer-controlled guidance systems for rockets, etc. This could be developed in cooperation with the drama department and then presented to another class or the entire school.

Resources & References

- NASA Tech. Briefs
  [Section III - Part 2, Periodicals/ Magazines]
- Smith, Howard. Exploring energy.
  [Section III - Part 1, Books]
- Adrian Vance Computer Program. Oil tycoon.
  [Section III - Part 8, Software]
- MAVCC - Exploring Technology Education. Introduction to technology: Section A-1, MVRC
  [Section III - Part 1, Books and Resources]
- Two posters available from Frey Scientific 89-90 catalog.
  - -A legacy of technological innovation
  - -Energy technology chart

  [Section III - Part 6, Sample Suppliers]
- McCrory, D. L. Resources in technology. Available from Creative Learning Systems
  [Section III - Part 1, Books and Resources]
- Aerospace software for the Apple IIE available from Pitsco.
  - -In search of space
  - -Physics
  - -Flight

  [Section III - Part 8, Software]
- Missouri introduction to communication technology guide.
  [Section III - Part 1, Books and Resources]
- Photo Voltaic News
  [Section III - Part 2, Periodicals/ Magazines]
- The Electronic School
  [Section III - Part 2, Periodicals/ Magazines]
- International Teleproduction Society (ITS)
  [Section III - Part 7, Associations/ Organizations]
- The Electronic Data Interchange Association
  [Section III - Part 7, Associations/ Organizations]

Content	**Teacher Plans & Activities**
V. Interface to Materials & Processing Technology A. Powering/Operating machines B. Controlling Operations C. CAD/CAM D. Transportation/Materials Handling	- Arrange for a field trip where students can see a working CNC system, a robot, CAD, or automated materials handling devices. - Have an industrial representative from a manufacturing company speak to the class. Focus the presentation both on current E&P applications in the manufacturing setting as well as anticipated future trends.
VI. Energy & Power Technology Impacts A. Economic B. Environmental C. Political D. Psychological E. Sociological	- Develop an energy deprivation simulation. Establish a situation where the energy supply is very limited. Students have to think of techniques for generating the needed power and/or conserving the available energy. - Set up a debate for and against the notion that information is an economic commodity. Those opposed could argue that tangible goods are the only real economic units. Those in favor need to identify ways in which information is a marketable commodity. - Obtain an environmental impact statement. Discuss what goes into such a statement. Why are the various components needed? How does economics affect outcome of such a report?
VII. Safety A. Personal B. Ecological	- Arrange for a guest speaker from a power company to present to class on issues related to personal safety. - Assign a research project on one of the following topics: the depletion of the earth's ozone layer; solid waste disposal; water pollution; land use; etc. Encourage students to address the causes and solutions as well as the potential damage if current practices go unchanged.
VIII. Scientific Foundations of Energy & Power Technology A. Applied Chemistry 1. Atomic structure & bonding 2. Formulas 3. Reactions	- Develop a presentation dealing with the fundamentals of some important technological reactions. These could include nuclear fission and fusion, the transformation of sugar into alcohol, fossil fuel combustion and by-products, rocket fuels, etc. Include a discussion about the role of various kinds of catalysts and useful by-product generation. This would be an excellent opportunity to work with an instructor from the sciences. - Check with a chemistry instructor in your school to see what E&P related experiments he/she might recommend for your students.

Student Activities

- Generate a drawing of a PC board on a CAD system.
- Go to a local factory and watch a robot in action. Prepare a short report for the class which deals with these questions. Why did they decide to use a robot in that situation? What was there about the job that made it necessary, financially feasible, better? Would you have made the same decision if you were in charge?
- Suppose your town or city were to be hit by an earthquake similar to the one experienced in San Francisco. Working in small groups predict what the impacts might be given massive damage to communications networks, transportation systems, utilities, etc. How would your life be affected most?
- Visit with a physician and inquire about the diseases and problems that he/she deal with that are related to the environment. Examples could be lung problems, work related problems, etc.
- Prepare a short report about predictions made by scientists concerning ozone layer depletion.
- Using the newspaper, clip as many E& P related accident reports as you can find. These could include electrical shock, transportation and industrial-related accidents. Combine and compare the clippings with others to see which types of situations were the most dangerous. Speculate as to what makes those situations dangerous.
- Make a simple methane generator to convert manure into fuel. Consult the chemistry teacher, a textbook, an article on alternative energy, etc, to find out what chemical changes occur during the change.
- Make a mobile using colored Styrofoam balls and toothpicks to model a chemical compound. Do an E&P related compound such as gasoline, alcohol, sugar, etc.

Resources & References

- Fischertechnik Catalog
  [Section III - Part 6, Sample Suppliers]
- Stafford, E. Complete handbook of robotics.
  [Section III - Part 1, Books]
- Rhino Robots, Inc
  [Section III - Part 6, Sample Suppliers]
- Missouri Dept. of Natural Resources
  [Section III - Part 4, Media Sources]
- AIT Video. Exploring Technology Education. People, Technology, and the Environment: Section A-2, MVRC
  [Section III - Part 4, Media Sources]
- YMT Video. Health and technologies & Risk, safety, and technology. MVRC
  [Section III - Part 4, Media Sources]
- Local Ham Club
  [Section III - Part 7, Associations/Organizations]
- American Coal Foundation (ACF)
  [Section III - Part 7, Associations/Organizations]
- American Public Power Association
  [Section III - Part 7, Associations/Organizations]
- Independent Energy
  [Section III - Part 2, Periodicals/Magazines]
- Mother Earth News
  [Section III - Part 2, Periodicals/Magazines]
- Scientific American
  [Section III - Part 2, Periodicals/Magazines]
- Nuclear News
  [Section III - Part 2, Periodicals/Magazines]
- Triangle Coalition Network News
  [Section III - Part 2, Periodicals/Magazines]

Content	**Teacher Plans & Activities**
B. Applied Physics 1. Thermodynamics 2. Laws of energy - entropy - enthalpy - conservation of energy	- Secure a basic physics textbook to use as a resource for E&P related information. - Develop a lecture/discussion covering basic physics including the basic principles and laws of electricity, thermodynamics, energy, and power conversion. - Obtain the services of the physics instructor at your school as a resource for activities appropriate to industrial technology instruction. - Take a course in basic physics at a local community college or university.
C. Applied Math 1. Algebraic operations 2. Geometry 3. Vectors 4. Exponents 5. Number base systems	- Develop a series of applied mathematics worksheets for E&P related problems. Some problems could be simple formula manipulations such as using Ohm's law, metric/customary unit conversions, and work. Consult with the mathematics and/or physics instructor at your school for resources.
D. Technology 1. Basic Machines 2. Technology & science 3. Evolutionary process	- Have the students develop a video presentation depicting the evolution of technology in your local community. In farming communities this could include images of pull-type combines, old tractors, antique butter churns, etc., as well as interviews with old-timers about how things used to be. The video could depict a progression into modern applications of technology in areas such as farm equipment, computers, automobiles, etc. The end result and discussion could be presented as an all school convocation.
E. Scientific Process 1. Experimentation 2. Development 3. Innovation	- Arrange to have someone from your community with a reputation for being an inventive, resourceful or particularly handy and creative with his/her hands, to visit the class. This could range from an older individual who always improves or adapts equipment to a person who has developed innovative ways of applying the computer to solve problems or improve situations. Use this person as a resource for exploring the creative process. How do ideas come? How does the person think through problems, obstacles, etc? - Create an imaginative problem that could be solved by students. - Visit a local science fair with the idea of students judging certain aisles as to whether scientific or technological processes were used.

Student Activities

- Select a metal container with a small opening. Stretch a balloon over the opening. Place the container over a source of heat. What happens to the balloon? Why?
- As a group, try to design a perpetual motion machine. Will it work? Why or why not?
- Read a K-Watt Hour Meter at home
- Determine the friction of different materials such as metal, wood, glass, formica, etc. Do a series of tests and record the results. Repeat the experiment using different lubrications such as oil, graphite, spray Teflon, wax, etc. Compare the results (see IACP).
- Design and build a pulley system to lift a 100# object with a system of three pulleys using only 10 pounds of force (e.g., 10 lb. test - fishing line).
- Put yourself in the role of an inventor. Identify a problem with something you own. Examples could include your car using too much gasoline, a cold room in your house, a burglar alarm system for your house/car, cats getting into your garbage, siblings wearing your clothing, etc. Think of a way that E&P related technology could be used to solve the problem. Don't worry about technical knowledge that you don't have or about whether a solution is possible. Simply identify the problem and propose a creative solution.

Resources & References

- Williams, J. E. Modern physics. [Section III - Part 1, Books]
- Bigliani, R. E. Technical physics. [Section III - Part 1, Books]
- Freeman, I. M. Physics made simple. [Section III - Part 1, Books]
- Hewitt, P. G. Conceptual physics. [Section III - Part 1, Books]
- Marcus, A. Introduction to applied physics. [Section III - Part 1, Books]
- Corcoran, C. L. Algebra, first course. [Section III - Part 1, Books]
- Jurgensen, R. C. Geometry. [Section III - Part 1, Books]
- Dolciani, M. P. Pre-algebra: An accelerated course. [Section III - Part 1, Books]
- Dolciani, M. P. Algebra 1. [Section III - Part 1, Books]
- YMT Video. The technology spiral: Four technology revolutions. MVRC [Section III - Part 4, Media Sources]
- SCINET [Section III - Part 2, Periodicals/ Magazines]
- Teachers Clearinghouse for Science and Society Education Newsletter [Section III - Part 2, Periodicals/ Magazines]
- TIES [Section III - Part 2, Periodicals/ Magazines]
- American Association for the Advancement of Science [Section III - Part 7, Associations/ Organizations]
- National Science Teachers Association [Section III - Part 7, Associations/ Organizations]
- Bullfrog Films [Section III - Part 4, Media Sources]

Missouri

Introduction to Energy & Power Technology

Unit 1: Energy & Power Technology Overview

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

Advisory Council Input:

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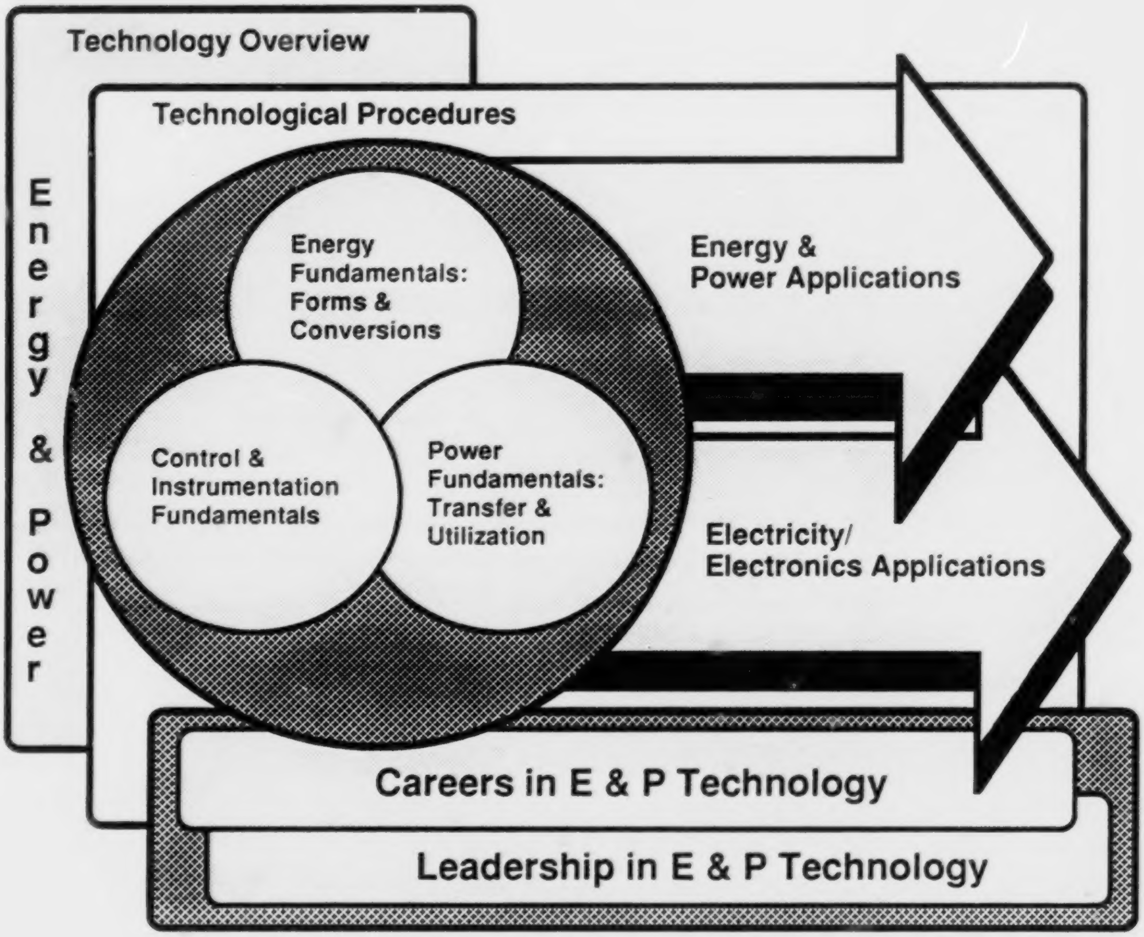
Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 2: Technological Procedures


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Two: Technological Procedures

OBJECTIVES: The purpose of this unit is to outline technological procedures which form the basis for the study of technology. These procedures provide an essential foundation and structure for the entire spectrum of technology including Communication, Materials and Processing, and Energy and Power.

COMPETENCIES -- The student will be able to:

1. Use various technical means of data acquisition to process information about the operation of a technical system. (2,I)
2. Use commercial information accessing/retrieval/storage mechanisms (such as Sweets, Mitchells Manuals, microform parts lists, computer data bases and the like. . .) to locate, secure and refile needed technological information. (2,II)
3. Describe the major categories of computer usage in industry. (2,III)
4. Use a selected computer language to perform a basic industrial function. (2,III)
5. Use selected types of computer input/output devices. (2,III)
6. Identify components of a typical computer; input, memory, output, and central processing unit. (2,III)
7. Describe the operation of a computer. (2,III)
8. Define the technical terms associated with computer technology. (2,III)
9. Identify assets and limitations of computers. (2,III)
10. Describe how computers are interfaced with other machines to operate processes. (2,III)
11. Use a computer language to write a useable program. (2,III)
12. Identify and describe important applications and uses of the computer in education, industry, business, or government. (2,III)
13. Process technological information using data analysis and data reduction methods such as computer or manual statistical process control procedures. (2,III)
14. Use a variety of sketching techniques to analyze and communicate how a selected existing technical device or system functions. (2,IV)
15. Report technological information using graphic, chart, tabular and textual presentations in printed, media or electronic forms. (2,IV)
16. Identify the role of experimentation and innovation in the development of energy related technical advances. (2,V)
17. Describe the role of serendipity in the invention process. (2,V)
18. Describe, in sequence, the steps used in the problem-solving process. (2,VI)
19. Employ individual and group problem-solving processes to arrive at alternative solutions, to assess them and subsequently to implement solutions to assigned technological problems. (2,VI)
20. Take a technological system and develop a detailed list of its major building blocks, system and building block inputs, system and building block outputs, statement of system goal, feedback mechanism, and sketch its configuration. (2,VII)
21. Design a technological system, using existing and/or newly developed components and/or building blocks, to meet an assigned set of design specifications. (2,VII)
22. Conduct technology assessment studies to evaluate the impacts and benefits of a specific technology or technological solution. (2,VIII)
23. Assess the effects that Power & Energy technology has made and will make on society, human needs, environment and values. (2,VIII)

*[notations in parentheses identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Experimentation
   A. Experimental Design
   B. Control of Variables
   C. Error Handling
   D. Data Collection Procedures
   E. Data Analysis
   F. Concluding & Reporting

Teacher Plans & Activities

- Have the students select an E&P related design problem. Possibilities include a solar collection device, building an electric motor, using a motion sensor in a feedback loop, etc. Brainstorm them through the experimentation process. Emphasize the documentation and reporting process. Have the students identify the essentials of the design and experimentation process. If possible see the process through the actual construction process.

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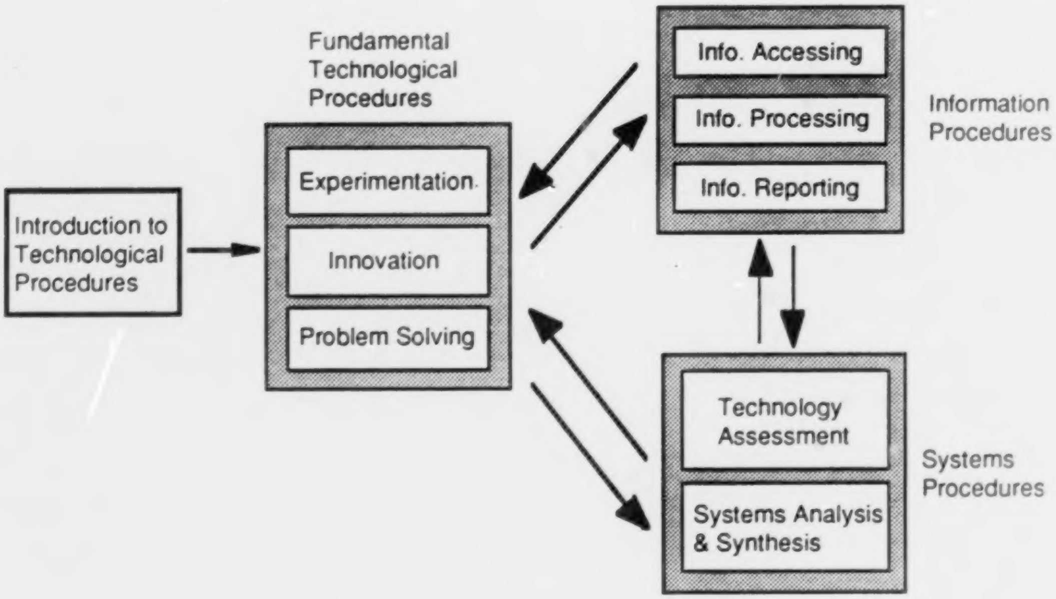
Lesson/Activity Outline


Fundamental Technological Procedures
Introduction to Technological Procedures
Experimentation
Innovation
Problem Solving
Info. Accessing
Info. Processing
Info. Reporting
Information Procedures
Technology Assessment
Systems Analysis & Synthesis
Systems Procedures

Student Activities

- Disassemble an appliance such as an automatic washing machine, dryer, toaster, jigsaw, drill, etc. to see how it works. Identify the components by specifying what they do in the system. Develop a chart that illustrates this.

Resources & References

- Odyssey of the mind: Problems to develop creativity. (1984)
[Section III - Part 1, Books & Resources]
- Bansford, J. D The ideal problem-solver.
[Section III - Part 1, Books & Resources]

Content	Teacher Plans & Activities
II. Information Accessing/Retrieval/Storage A. Trade & Government Publications B. Computer Data Bases C. Reference Publications & Sources D. Associations, Centers, Organizations	- Demonstrate the use of a modem to access either a national or a local database or bulletin board. While it may not be possible to access one directly related to E&P or Industrial Technology Education, demonstrating the process is nevertheless valuable. Emphasize the potential of the process.
III. Information Processing A. Computer/Machine Interface B. Calculating C. Abstracting/Summarization D. Pattern Recognition E. Compiling	- Develop a series of E&P-related mathematical problems. Demonstrate how to operate a hand-held calculator. Have students perform solutions. - Collaborate with the school's science and physics instructors to have them provide basic experimentation with factors such as light, electricity, heat, sound, magnetism, etc. Then, demonstrate direct application of these principles to ITE. - Pull together a set of slides showing the diversity of E&P technology. These could include transportation-related items, computers, robots, ICs, electrical substations, and much more. Divide the students into two groups. Have each group organize the slides into some format which follows a pattern that they establish. Emphasize the importance of developing a pattern and/or conveying a message. Have students select and record music which enhances the communication of the identified pattern. Compare the differences in the patterns identified.
IV. Information Reporting A. Design & Layout B. Reporting Formats 1. Narrative reports 2. Graphs & charts 3. Displays 4. Graphics 5. Media presentations C. Oral Presentations	- Have small groups of students report the results of an experiment they conduct or one they have read about. The experiment could be anything E&P-related such as wind tunnel wing design, experimentation for aircraft, dynamometer tests of various engine tune-up configurations, etc. Using the identical information, have each group independently prepare a report. Encourage students to be creative in terms of format, design and presentation media. The main criterion should be effective communication. Have groups assess the effectiveness of the various formats as a wrap-up for the activity and formally compare their assessments to your own.
V. Innovation A. Inventiveness B. Stimulants C. Barriers D. Insight	- Have the students prepare a report about an inventor such as Edison, Ford, George Washington Carver, Franklin, etc. Identity factors like, needs, inspiration, key events, or perception of need, etc. found in their inventions. Also have them speculate on the role of luck, serendipity, and inventive style.

Student Activities

- Suppose that room temperature superconductivity is feasible. Develop a design for an object that takes advantage of the development. This could be a tool, a transportation vehicle, a communication device, etc.
- Use a CD-ROM database to locate an article related to an E&P interest. This resource could be available at a larger library, a local computer store, or directly through services such as COMP-U-SERVE.
- Check with the librarian to find a reference source listing associations and organizations. Locate an E&P related organization that is interesting to you. Examples include NASA, Edison Electric Institute, the Illumination Engineering Society, Solar Energy Research Institute, national or regional computer user groups, a model train club, or an electronics applications organization. Send them a letter requesting information regarding publications, resources, and their program of work. Particularly ask for materials that contain activities that you can actually do.
- Develop a simple three-level outline of a technological product or process.
- Using a magazine (Popular Science, Popular Mechanics, Hot Rod, PC Magazine, etc.) locate as many different kinds of formats for information reporting as you can. Examples include charts, graphs, displays. Compete with other students for the most unusual, the greatest quantity, etc.
- Select a set of instructions that describes how to assemble an electronic device, a bicycle, etc. Have a fellow student critique the directions. Are they clear? Do the illustrations convey enough of the right kind of information? If you knew nothing about the product would you be able to do it? Suggest ways that the instructions could be improved. See who can locate the worst set of instructions.
- View films or videos from various companies describing technological advances or changes made to their products. Examples could include tire tread design, fuel injection changes, etc. Identify the problem-solving stages that the company went through.

Resources & References

- National Technical Information Service (NTIS)
  [Section III - Part 5, Resource Centers]
- AIT Video. Exploring Technology Education. Communication: Section B, MVRC
  [Section III - Part 4, Media Sources]
- Solar Energy Research Institute
  [Section III - Part 5, Resource Centers]
- NASA
  [Section III - Part 5, Resource Centers]
- Edison Electric Institute
  [Section III - Part 5, Resource Centers]
- Illumination Engineering Society
  [Section III - Part 7, Associations/ Organizations]
- How to build a better mouse trap. Program for the Apple II
  Available from Vernier Software.
  [Section III - Part 8, Software]
- The Electronic Data Interchange Association.
  [Section III - Part 7, Associations/ Organizations]
- YMT Video. Decisions, decisions, decisions, MVRC
  [Section III - Part 4, Media Sources]
- Popular Science
  [Section III - Part 2, Periodicals/ Magazines]
- Odyssey of the Mind, Creative Learning Systems, Inc.
  [Section III - Part 5, Resource Centers]
- Modules of Technology Problem-solving book.
  [Section III - Part 1, Books & Resources]
- Phillips Petroleum
  [Section III - Part 5, Resource Centers]
- Beyond 2000. Discovery Channel T.V. program.
  [Section III - Part 4, Media Sources]
- Modern Talking Picture Service
  [Section III - Part 4, Media Sources]

Content

VI. Problem-solving Processes

- A. Problem-solving Models
  1. Identify problem
     - -Analyze problem
     - -Analyze the problem's context
     - -Define & clarify the problem
  2. Establish solution criteria
     - -Identify appropriate criteria
     - -Identify constraints and limitations
     - -Weigh criteria according to the nature of the problem
     - -Develop a design brief
  3. Assemble pertinent information
     - -Search for information
     - -Analyze information
     - -Synthesize appropriate information
  4. Formulate alternative solutions
     - -Brainstorming
     - -Remove barriers to creative juices
  5. Evaluate alternatives
     - -Apply solution criteria
     - -Select optimum solution
  6. Implement prototype solution
     - -Develop prototype solution
     - -Produce drawings
     - -Theoretical testing
     - -Plan implementation of solution
     - -Implement prototype solution
     - -Evaluate prototype solution in operation
  7. Refine solution
     - -Communicate the solution
     - -Refine the prototype solution
     - -Implement the refined solution
     - -Monitor the solution appropriately
- B. Research and Development Procedures
  1. Experimental method
  2. Testing
  3. Design briefs
  4. Experimentation
  5. Design
  6. Implementation
  7. Prototyping

Teacher Plans & Activities

- Develop a presentation which illustrates and describes the essential components of the problem-solving process.
- Prepare a design brief and then have groups develop a prototype of the best solution. Example problems include hang gliders, boats, a Mars rover, mouse trap vehicles, an aerobie, a miniature space shuttle, a robot, etc.
- Provide student with an E & P-related system. Examples could include a solar collector, a battery operated device, a robot, etc. Have them use a schematic or block diagram to present an overview of the system, identify components, input/output mechanisms, describe the measurement of input/out and instrumentation and control devices.
- Have the students design a parachute with an egg inside a plastic bag (no mess) so that the egg will not break.
- Invite a professional to speak concerning the problem-solving process as they experience it in their work. Examples could include persons from fields as diverse as a medical doctor, an engineer, an auto mechanic, a power utility manager, an office manager. Direct the discussion so that the person addresses a broad range of issues related to problem solving including problem analysis and clarification, brainstorming possible solutions, how they organize the possibilities, collaboration with other professionals, etc.
- Arrange for a field trip to an E&P research and development facility. Possibilities might include a solar energy or wind generation company, a manufacturing facility with on-site R&D, etc. Provide for the chance to have a representative describe their R&D process. If possible, encourage them to talk through the development of a single product from beginning to end. Back in class, lead a discussion of how closely that example compared with the process as you presented it in class.
- Design an R&D situation where student are to design a small egg transporting vehicle which will move down an incline surface. At the end of the incline, the vehicle will stop abruptly against an immovable wall. The design should be such that the egg will not break upon impact.

Student Activities

- Using a box of common technological components provided by your instructor, employ the problem-solving process to design and build a device to accomplish a specified task such as blowing out a candle, breaking a balloon filled with water, etc.

- Use a baggie full of supplies -- 2 balloons, 2 paper clips, a pipe cleaner, a straw, 6" of masking tape, 20' of fishing line, and tacks. Stretch and secure the full length of fishing line between two objects. The object of this exercise is to get a pipe cleaner man across the distance between the two anchor points using only the supplies in the bag.

- Trouble-shoot a system that is not working properly. Develop a diagram of the subsystems. (Examples of subsystems in an internal combustion engine are the fuel system, the ignition system, etc.) Identify key components within each subsystem. Test the components and subsystems until the problem is solved.

- Working in pairs, both you and your partner breadboard the same electronic circuit without looking at what each other are doing. After completing them, switch breadboards, test, and trouble-shoot one another's circuits. Be certain to pay attention to both personal and equipment safety.

- Make a mechanical model car. Include components from each of the mechanical, electrical and fluid systems e.g. syringes, gears, rubber bands, springs, mousetraps, weights, etc. Include a guidance system to run it on a specified path. Have a contest to see whose design works the best.

- Make a mousetrap powered water vehicle.

- Think of a method by which it would be possible to analyze and measure the energy output from a firecracker, a model rocket, a small gas engine, an automobile headlamp, etc.

Resources & References

- How it works - science and invention. Set of encyclopedias available from H. S. Stuttman Inc. [Section III - Part 1, Books & Resources]
- TAM #2: Problem-solving. Missouri Introduction to M&P Guide [Section III - Part 1, Books & Resources]
- TAM #1: . First Week Activity. Missouri Introduction to M&P Guide [Section III - Part 1, Books & Resources]
- Carpenter, I. Problem-solving in school science. [Section III - Part 1, Books & Resources]
- AIT Video. Exploring Technology Education. Introduction to Technology: Section A, MVRC [Section III - Part 4, Media Sources]
- Kivenson, G. The art & science of inventing. [Section III - Part 1, Books & Resources]
- Malo, G. E. Technology workbook: Problem-solving. [Section III - Part 1, Books & Resources]
- Rye, K. J. Creative group problem-solving in technology education. [Section III - Part 1, Books & Resources]
- MAVCC - Exploring Technology Education. Section A, MVRC [Section III - Part 1, Books and Resources]
- Vare, E. A. Mothers of invention. [Section III - Part 1, Books & Resources]
- Yoshioka, R. Thousands of science projects. [Section III - Part 1, Books & Resources]
- American Heritage of Invention & Technology [Section III - Part 2, Periodicals/ Magazines]
- JETS [Section III - Part 7, Associations/Organizations]
- TAM #3: Designing & Using Experiments. [Section II - Missouri Introduction to E&P Guide]

Content	**Teacher Plans & Activities**
VII. Systems Analysis & Synthesis A. Systems terms & definitions 1. Components 2. Subsystems 3. Supra systems 4. Input 5. Output 6. Processing 7. Feedback 8. Environment B. The Black Box Approach C. Systems Synthesis D. Systems Planning	- Give the students an unfamiliar system. Have them dissect it into its component building-blocks/modules. Have them graphically depict the interrelationships between the energy and power exchange. Examples of these types of systems could include FAX machines, electrostatic copiers, ion space vehicle propulsion mechanisms, gas turbines, a photocopier, etc.
VIII. Technology Assessment A. Post-implementation Evaluation B. Cost-benefit Analysis C. Technology Assessment Process D. Technological Standards	- Develop an energy deprivation exercise where students are asked to imagine a world without some specific energy-driven appliances, devices, etc. that they use on a daily basis.

Student Activities

- Go to a library which has either on-line database retrieval services or CD-ROM. Do a search on an E&P related topic such as transformers, thermo properties, solar power, super conductors, cooling systems, magnetism, etc. See the resources section for additional hard copy resources.
- Break into small groups and discuss the question, "What would our community be like without a number of common items such as electricity? Come back as a total group and compare answers checking similarities.
- Go one step further (from previous activity). Look beyond the inconvenience problems. What kinds of safety and community health problems would be caused by being forced to do without electricity, water, or other services?
- List what you would have to give up in and around your home if electricity had not been developed. What would be the alternatives that you would have under those circumstances? Hint: An excellent resource could be a grandparent or an older individual in your community.

Resources & References

- TAM #2: Adventures in Systems Analysis.
  [Section II - Missouri Introduction to E&P Guide]
- Compu-serv
  [Section III - Part 5, Resource Centers]
- Social Issues Resources Series (SIRS)
  [Section III - Part 5, Resource Centers]
- NewsBank Index
  (CD-ROM)
  (current events and reports)
  [Section III - Part 4, Media Sources]
- Opposing Viewpoints Sources
  Science and Technology (Vol. 1)
  (contains a collection of selected magazine articles related to science and technology issues.)
  [Section III - Part 1, Books & Resources]
- TAM #4: The Technology Assessment Process.
  [Section II - Missouri Introduction to E&P Guide]

Missouri

Introduction to Energy & Power Technology

Unit 2: Technological Procedures

Instructor Notes:		
Start: _____	End: _____	Items to Order

Suggested Revisions:

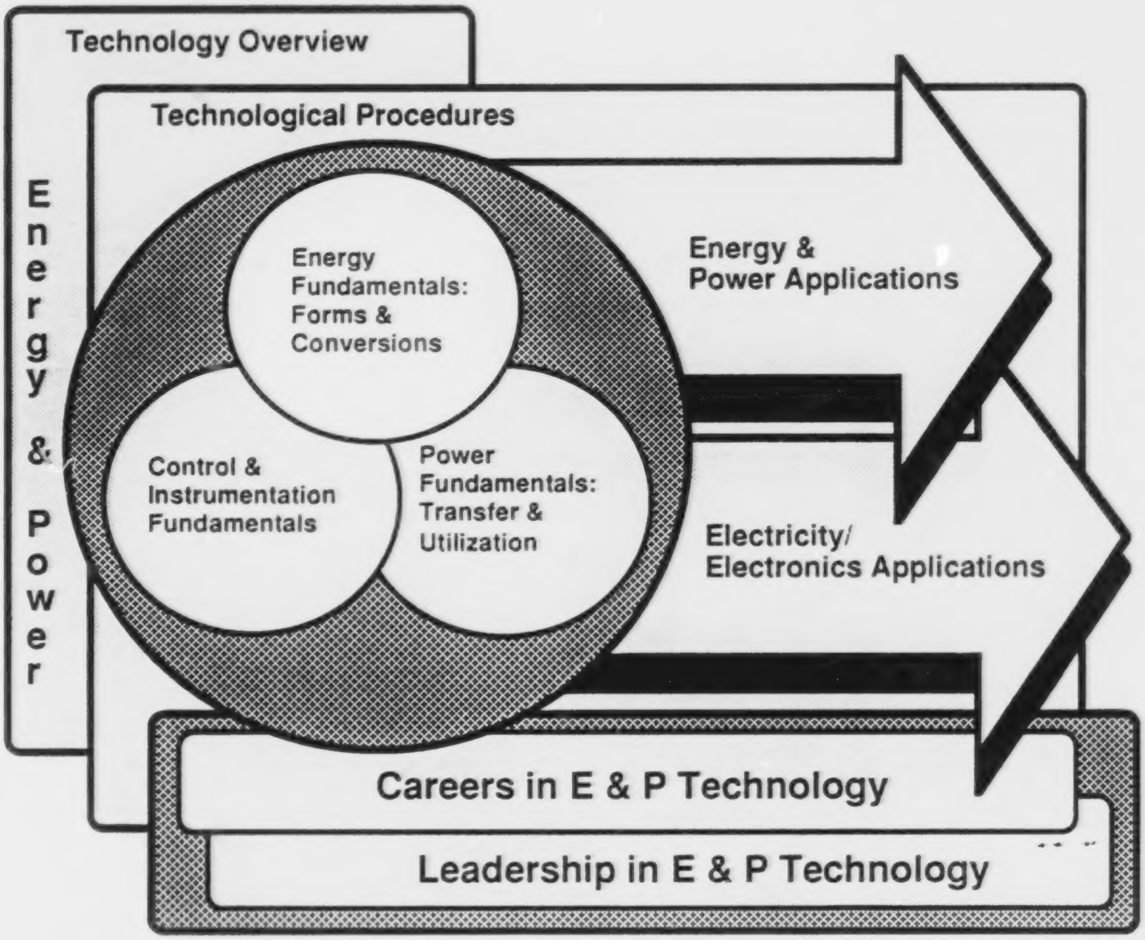
Advisory Council Input:

Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 3: Energy Fundamentals: Forms & Conversions


Technology Overview
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Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Three: Energy Fundamentals: Forms & Conversions

OBJECTIVES: The purpose of this unit is to explore the fundamentals of energy including sources, conversions, and measurement systems.

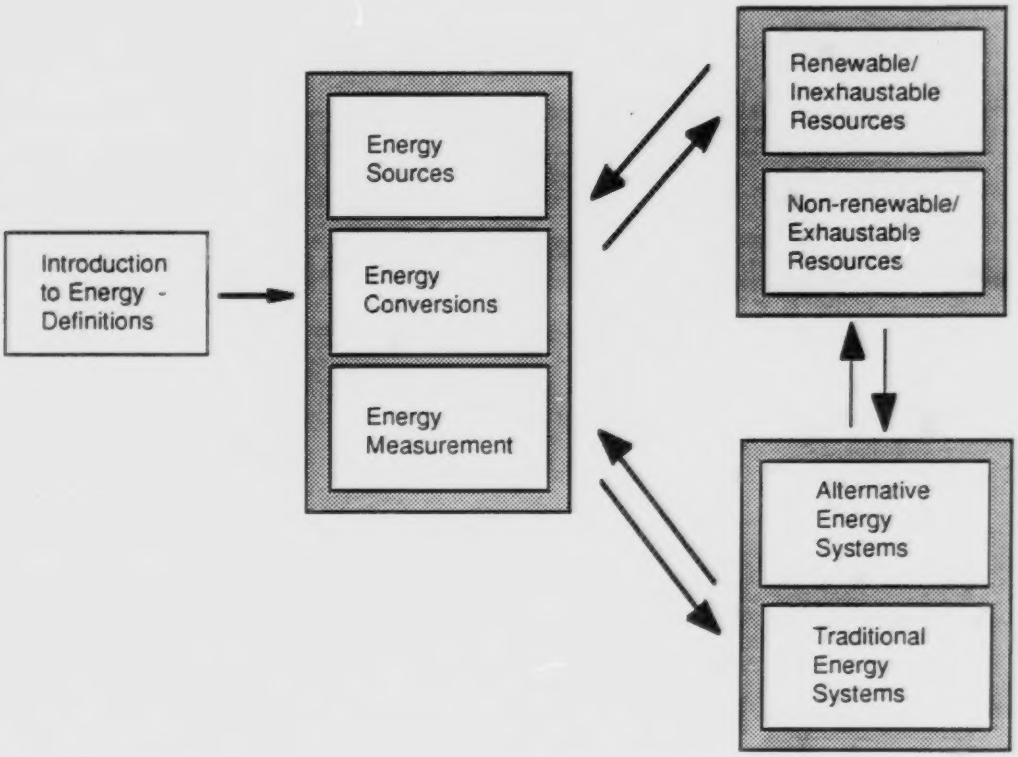
COMPETENCIES -- The student will be able to:

1. Demonstrate the principles of heat transfer using common laboratory equipment. (3,I)
2. Explain the First Law of Thermodynamics (Law of Energy Conservation) and illustrate its application in key energy processes. (3,I)
3. Describe the Second Law of Thermodynamics (Diminishing of available of energy) and how it relates to closed energy systems. (3,I)
4. Recognize and respond to the need for energy conservation (electrical, water, fossil fuels) in residential, commercial, industrial, and transportation applications. (3,I)
5. Identify and evaluate the merits of various energy conservation measures for a home/industry. (3,I)
6. Describe and illustrate the basic concepts of storage, transmission and control of various forms of energy. (3,I)
7. Define common terms related to the study and use of energy. (3,I)
8. Chart the basic trends of energy use and growth patterns. (3,I)
9. Define the units (customary and metric) used in measuring energy and make conversions among them. (3,II)
10. Describe the characteristics of major energy sources; chemical, mechanical/kinetic, radiant, electrical, thermal, nuclear. (3,III)
11. Explain the energy conversion process, and the necessary apparatus, between any two energy sources. (3,IV)
12. Secure and evaluate feedback to assess the effectiveness of an energy conversion method. (3,IV)
13. Build experimental/prototype energy conversion demonstrators and measure their effectiveness. (3,IV)
14. Use laboratory equipment to measure energy conversion variables such as fuel efficiency, heat loss and the like. (3,IV)
15. Define efficiency in energy conversion terms. (3,IV)
16. Identify the status, availability, significance, economic and environment advantages and disadvantages of various alternative energy systems e.g., solar, wind. . . , in your community/region. (3,V)
17. Identify renewable and non-renewable energy sources in the world, in the U.S.A., and in Missouri. (3,V,VI)
18. Differentiate between, and sketch the operation of, internal and external combustion engines. (3,VI)
19. Describe the basic principles and applications of nuclear power. (3,VI)
20. Describe the principles of operation and list the various components of two-cycle/four-cycle engines. (3,VI)
21. Describe the basic principles of operation for rotary combustion engines. (3,VI)
22. Describe the basic principles of operation for diesel engines. (3,VI)
23. Describe the basic principles of operation for jet and rocket engines. (3,VI)
24. Define the basic principles of piston and turbine use of steam power. (3,VI)
25. Contrast the basic concepts of coal, petroleum, natural gas and other fossil fuel utilization. (3,VI)
26. Describe major physical and social problems and possible solutions concerning alternate energy sources. (3,VII)
27. Describe alternative energy systems based on each major energy source. (3,VII)
28. Debate the advantages and disadvantages of nuclear generation of electricity. (3,VII)
29. Measure internal combustion engine performance utilizing a variety of test instruments. (3,VI)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content	Teacher Plans & Activities
I. Basic Definitions and Concepts A. Energy B. Conservation C. Conversion D. Each Form E. Open & Closed Systems F. Efficiency	- Have students do a series of word association interviews throughout the school. Words, such as energy, conservation, efficiency, conversion, etc. could be thrown out for response. Encourage quick, off-the-top-of-the-head types of responses (whatever first comes to mind, out of whatever context). Have students write down the responses and bring them in for discussion.
II. Energy Measurement A. Standards of Measurement 1. Metric 2. Customary	- Have students make a customary-metric formula conversion list for later use in tests or for display purposes.

Lesson/Activity Outline


Introduction to Energy - Definitions
Energy Sources
Energy Conversions
Energy Measurement
Renewable/ Inexhaustable Resources
Non-renewable/ Exhaustable Resources
Alternative Energy Systems
Traditional Energy Systems

Student Activities

- List the energy conversions that occur naturally in nature. Examples include photosynthesis, fossil fuel development, fire, geological shifts (earthquakes), etc.

- Convert key E&P measurements from the customary to the metric system. Include your weight, the distance from home to school, the amount of water it takes to take a bath, the temperature of the warmest known superconductivity, the maximum torque for your automobile engine, etc.

Resources & References

- Smith, Howard. (1985). Exploring energy.
  [Section III - Part 1, Books & Resources]

- Zales. Energy, power, and transportation technology.
  [Section III - Part 1, Books & Resources]

- Kozak, M. Discovering technology: Energy, power and transportation.
  [Section III - Part 1, Books & Resources]

Content	**Teacher Plans & Activities**
B. Units of Measurement 1. Metric - Joules - Calories 2. Customary - Foot-pounds - British thermal units (BTU) 3. Conversion between Units	- Conduct a competition where groups see who can convert measures the most rapidly, with the greatest amount of accuracy, etc. - Organize a debate for and against the merits of the metric and the customary measurement systems. Include factors such as politics, the economics of retooling, standardization, re-education, etc.
C. Measurement Instruments 1. Thermometer D. Measurement Techniques	- Arrange for a representative from a rural electrical cooperative to visit the school to demonstrate or talk about power conversion and energy rate calculation. - Work with the TAM #18 entitled "Using Electronic Instrumentation."
III. Energy Sources A. Chemical B. Mechanical/Kinetic C. Radiant D. Electrical E. Thermal F. Nuclear G. Wind H. Human	- Conduct a brainstorming session having students think of as many energy sources as they can. - Arrange for a field trip to a petroleum refinery if there is one in your area. - Supervise the design, construction and operation of a methane generator from animal waste. - Develop a competition where students construct an electrical generator from a stationary bicycle. Connect the system to an electrical appliance such as a television set for operation testing. Be sure to check the setup for electrical safety. - Arrange for a field trip to a nuclear power plant if there is one in your area. - Present an overstatement of a position in support of nuclear power. The case could include a downplaying of the environmental risks, a case for national security and economic considerations over personal health risks, etc.
IV. Energy Conversions A. Common/Uncommon Conversions B. Useful/Wasteful Conversions C. Constructive/Destructive Conversions D. Single/Multiple Stage E. Examples	- Obtain the Apple II program "Toy Shop" which simulates steam power. - Develop a worksheet for calculating energy conversions (e.g. between Watts and BTU). Include a factor for energy loss.

Student Activities

- Write a BASIC language program for converting between the metric and customary measurement systems.
- Conduct an audit of your home's water heating system. How much energy is actually being used? Calculate the efficiency of the system. What alternatives would you suggest?
- Develop a means for measuring the output of a passive or active solar collector.
- Use a photometer to obtain light level readings in your school or in your home. Compare the obtained readings with the specifications for residential or commercial lighting.
- Build a solar oven. Use the oven to dry food such as apples or beef jerky.
- As a followup to the previous activity, visit with a nurse or a physician about the effects of heat on human tissue. Particular concern should be addressed to the effects of solar radiation on the human skin.
- Engage in a form of rigorous physical activity such as running up and down a set of stairs. Calculate how much energy was required to do this. Record pre-and post-measurements for body temperature and weight. What does this tell you about energy conversion? How efficient is your body as an energy converting mechanism?
- Use a bathroom scale as a squeeze meter. Have a contest to see who's the strongest. This will provide a good test for leverage, muscle design, size, etc.
- Participate in a water shed simulation. Provide documentation of what kind of energy conversion is occurring.

Resources & References

- Schwaller, A. Transportation, energy, and power.
  [Section III - Part 1, Books & Resources]
- MAVCC - Exploring Technology Education. Overview of Energy: Section E-1, MVRC
  [Section III - Part 1, Books and Resources]
- AIT Video. Exploring Technology Education. Overview of Energy: Section E-1, MVRC
  [Section III - Part 4, Media Sources]
- Landers, Jack. (1986). Home repair and maintenance.
  [Section III - Part 1, Books & Resources]
- Illumination Engineering Society
  [Section III - Part 7, Associations/ Organizations]
- Architectural & Engineering Manuals
  [Section III - Part 1, Books & Resources]
- Edison Electric Institute
  [Section III - Part 5, Resource Centers]
- Oak Ridge National Laboratory
  [Section III - Part 5, Resource Centers]
- U.S. Dept. of Energy
  [Section III - Part 5, Resource Centers]
- Mother Earth News.
  [Section III - Part 2, Periodicals/ Magazines]
- Popular Science.
  [Section III - Part 2, Periodicals/ Magazines]
- Popular Mechanics.
  [Section III - Part 2, Periodicals/ Magazines]
- Park, J. (1981). The wind power book. Available from Transteck
  [Section III - Part 1, Books & Resources]
- TAM #5: Energy Conversions.
  [Section II - Missouri Introduction to E&P Guide]

Content

V. Renewable/Inexhaustible
  A. Definitions
  B. Common & Uncommon
    1. Gasohol
    2. Methanol
    3. Bioconversion
    4. Wood
    5. Solar
    6. Hydroelectric
    7. Wind
    8. Oceanic
    9. Solar-salt ponds
    10. Hydrogen
    11. Geothermal
    12. Wave

VI. Non-renewable/Exhaustible
  A. Definitions
  B. Common & Uncommon
    1. Fossil Fuels
      - Coal
      - Oil (petroleum)
      - Crude oil
      - Shale oil
      - Tar sands
      - Natural gas
    2. Uranium

VII. Alternative Energy Systems
  A. Geothermal
  B. Wave
  C. Solar Rays
  D. Breeder Reactors
  E. Co-generation

Teacher Plans & Activities

- Invite a guest speaker who is actively involved in some form of experimentation with alternative energy sources. This could include work with wood furnaces, solar energy, methanol production, wind generators, etc. Have them present what they're doing. Emphasize the creative, problem-solving, innovation process. Also inquire about any special safety considerations.
- Organize a field trip to see an uncommon energy conversion setup that someone in your community has developed.
- Establish some parameters for an energy-related design project. The problem could be framed in terms of alternatives needed to replace a current practice where energy costs have skyrocketed, become scarce, pose a health hazard, or are environmentally unsafe. Have the class think through the design of an alternative system(s).
- Contact Briggs and Stratton for plans on how to make a cut-away model of an old small gas engine.
- Demonstrate internal combustion using a glass (visible) engine demonstration model.
- Collaborate with a chemistry instructor at your school to develop a presentation on fossil fuels and how they have developed over the centuries. Where possible treat the subject's chemical aspects.
- Have students conduct an energy audit of their home. Design the exercise to determine both the amount of energy being consumed as well required levels. Have them develop proposals for alternative energy sources which would meet the energy requirements.
- Arrange for a field trip to a nuclear power plant.

Student Activities

- Make fuel briquettes from a mixture of sawdust, sand, and wax. Caution: Be certain to pay particular attention to safety concerns when working with these types of flammable materials.
- Design and build a device of your choice using one or more of the renewable resources.
- Design and build a solar collection device for heating air or water. Record the changes in temperature achieved.
- Contact the local weather service about the wind patterns in your area. What major factors influence their velocity, direction, patterns, etc. On the basis of information obtained make a case either for or against the use of wind powered electrical generation in your locality.
- Design and construct a used-oil heater. Be certain to incorporate safety considerations into your design. Considerable heat could be generated which could pose serious threats of fire or injury.
- Construct a number of different propeller shapes out of paper. Develop a means for testing the difference in efficiency among the different shapes.
- Make a geographic map of the locations of non-renewable resources in your state and/or region.

-Along with a partner, do a creative thinking exercise. Suppose that all major sources of renewable resources had been used up. What do you imagine that transportation would be like? What about the power for homes? What would be the possible sources of energy that could be used? Which would be the best? Would the best be economical?

Resources & References

- Solar Energy Research Institute [Section III - Part 5, Resource Centers]
- Natural Wood Institute of America [Section III - Part 7, Associations/ Organizations]
- Barling, John. (1979). Solar fun book. [Section III - Part 1, Books & Resources]
- Forest Products Lab [Section III - Part 5, Resource Centers]
- Sandia Laboratories [Section III - Part 5, Resource Centers]
- Making energy from the sun. Lab Books. [Section III - Part 1, Books & Resources]
- Nuclear News [Section III - Part 2, Periodicals/ Magazines]
- "Nova" film on wave conversion. [Section III - Part 4, Media Sources]
- Briggs and Stratton [Section III - Part 6, Sample Suppliers]
- YMT Video. Energy for Societies. MVRC [Section III - Part 4, Media Sources]
- Mother Earth News [Section III - Part 2, Periodicals/ Magazines]
- Morrison, J.W. The Missouri energy saving handbook for homeowners. Available from the Missouri Dept. of Natural Resources. New York: Harper and Row Publishers. [Section III - Part 1, Books & Resources]

Leckie. Other homes and garbage. Sierra Club Books [Section III - Part 1, Books & Resources]

Missouri

Introduction to Energy & Power Technology

Unit 3: Energy Fundamentals: Forms & Conversions

Instructor Notes:	
Start: _____ End: _____	Items to Order

Suggested Revisions:

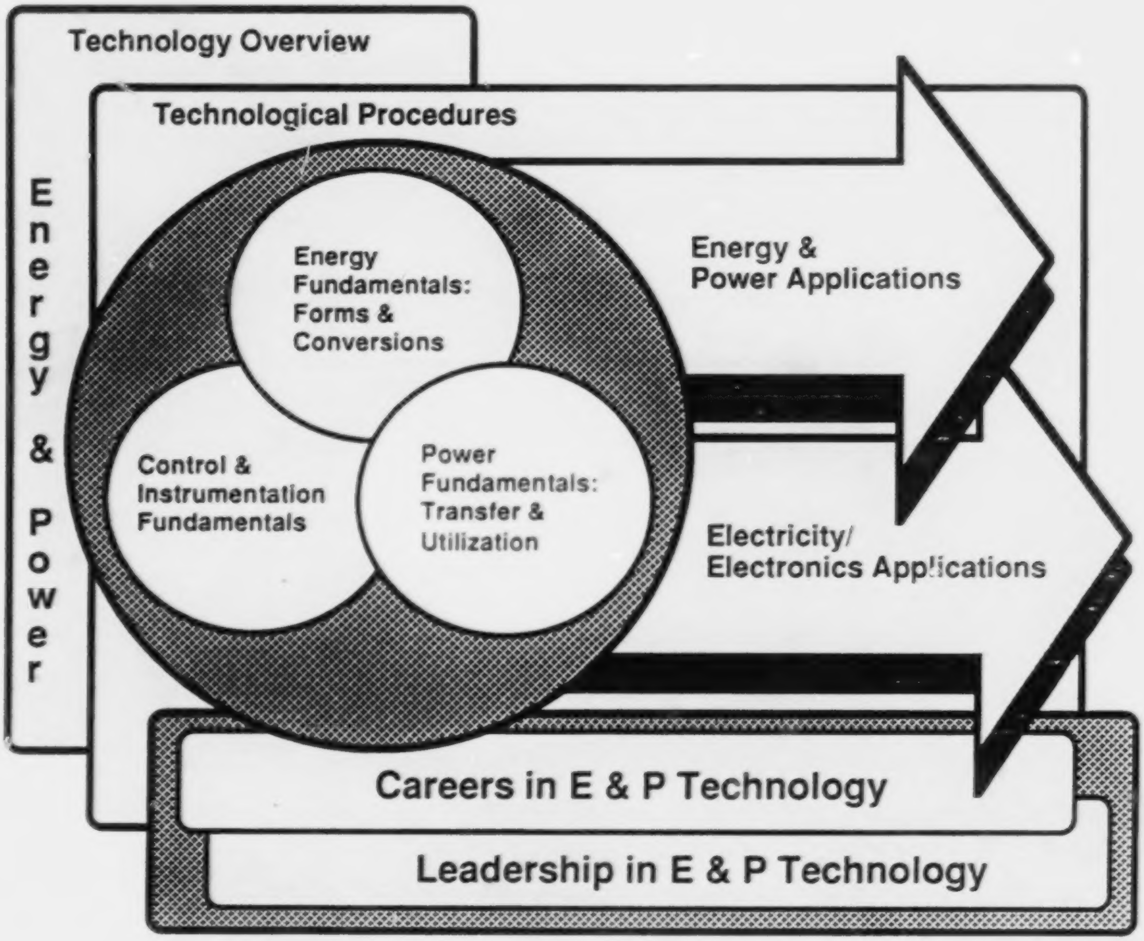
Advisory Council Input:

Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 4: Power Fundamentals: Transfer & Utilization


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Four: Power Fundamentals: Transfer & Utilization

OBJECTIVE: The purpose of this unit is to examine fundamental principles of power technology including power sources, measurement, transmission and conversion systems.

COMPETENCIES -- The student will be able to:

1. Develop an operational definition and concept of power systems. (4,I)
2. Define the basic terms commonly used in power systems. (4,I)
3. Explain lubrication systems, their function and importance in power technology. (4,I)
4. Read technical and working drawings and prints to secure needed information. (4,I)
5. Describe the applications of pneumatics in a technological society. (4,II)
6. Describe the applications of hydraulics in a technological society. (4,II)
7. Construct fluid power systems utilizing typical components. (4,II)
8. Manipulate common test instruments to analyze fluid power circuits. (4,II)
9. Use tools and equipment to assemble mechanical power transmission systems and mechanisms. (4,II)
10. Describe the basic instruments and equipment used in power transmission. (4,II)
11. Describe the types of power systems used in our society. (4,II)
12. Illustrate and explain the six simple machines and their applications. (4,II)
13. Use instrumentation to measure power. (4,III)
14. Use and convert basic units measurement for power systems. (4,III)
15. Describe the characteristics and advantages/disadvantages of each major type of power transmission system: pneumatic, hydraulic, mechanical, electrical. (4,IV)
16. Describe the internal combustion engine's importance in transportation and industry. (4,IV)
17. Employ a systematic design process to produce a power transmission system that meets the assigned design specifications. (4,IV)
18. Explain the principles of motor operation. (4,IV)
19. Select motors to suit the characteristics of the application. (4,IV)
20. Build demonstrator power conversion and transmission devices. (4,IV)
21. Explain the basic concepts of mechanical transmission devices. (4,IV)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Definitions
   A. Efficiency
   B. Power
   C. Work
   D. Transfer
   E. Friction
   F. Mechanical Advantage
   G. Duty Cycle
   H. Rate
   I. Dynamic
   J. Fluid
   K. Internal Combustion

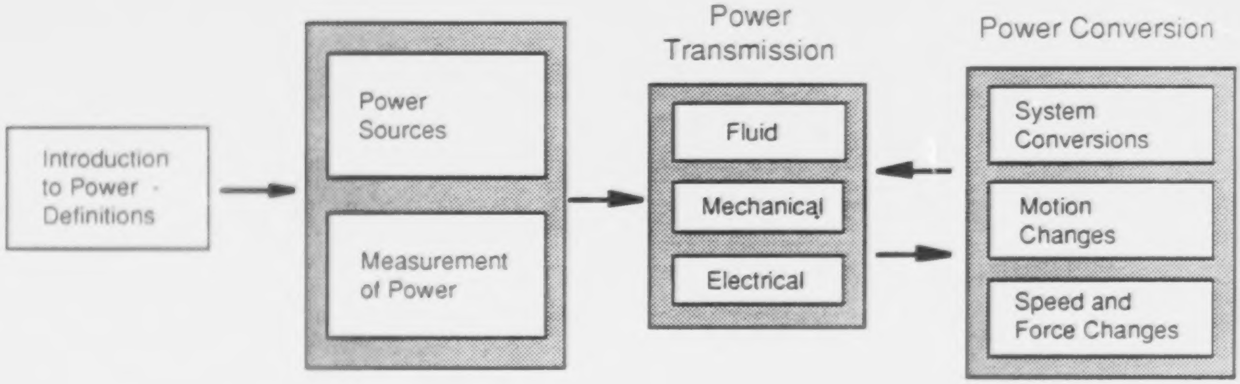
Teacher Plans & Activities

- Prepare and administer a handout for students requiring them to research the meaning of basic terms related to power technology.

- Discuss the major safety issues related to power technology. Include illustrations of actual experiences or accidents which have occurred related to power.

- Have a group of students develop a display for a large bulletin board or other display area. Divide the area into two parts. On the left side depict a variety of energy sources. On the right side depict a number of power applications. Try to arrange for this to be in a prominent display area which exposes it to the entire school.

Lesson/Activity Outline


Introduction to Power - Definitions
Power Sources
Measurement of Power
Power Transmission
Fluid
Mechanical
Electrical
Power Conversion
System Conversions
Motion Changes
Speed and Force Changes

Student Activities

- Make a video which depicts power and power-related concepts such as work, friction, mechanical advantage, etc. Sample visual images could include a person lifting weights, a diesel locomotive, a jack hammer, a dragster, a bulldozer, and more. Set the video to music that corresponds to the kind and intensity of power being displayed.
- Develop a short paragraph which completes one of the following segments:

  Efficiency is...
  Power is...
  Work is...
  Friction is...
  Mechanical advantage is...

- Working in small groups, select what you think is the most efficient machine in your ITE laboratory. State the reasons why you selected it. Debate the other group(s).

Resources & References

- Hacker, M. & Barden, R. Technology in your world.
  [Section III - Part 1, Books & Resources]
- TAM #9: Fundamentals of Fluid Power.
  [Section II - Missouri Introduction to E&P Guide]
- Atteberry, P. H. Power mechanics.
  [Section III - Part 1, Books & Resources]
- Karwatka & Kozak, M. Discovering technology: Energy, power, & transportation.
  [Section III - Part 1, Books & Resources]
- Bohn, R. & MacDonald, A. Power: Mechanics of energy control.
  [Section III - Part 1, Books & Resources]
- Toffolon, J. E. Power technology.
  [Section III - Part 1, Books & Resources]

Content	Teacher Plans & Activities
II. Types of Power Transmission A. Fluid 1. Types of fluid power systems -Pneumatic -Hydraulic	- Supervise the control of a simple hydraulic or pneumatic device with a microcomputer. - Have students build a mechanical arm device to be controlled by syringes. Arrange for two different types of operation. First, have them operate the syringes with air (pneumatics). Second, repeat the movements with water (hydraulics). Structure the experiment such that comparisons can be made in the power, efficiency, and relative advantages and disadvantages of each type.
2. Devices in fluid power systems -Accumulators -Actuators -Compressors -Cylinders - Flow controls -Pumps -Regular -Valves	- Have the students design and construct a complete air-compressor unit using salvaged and fabricated components and parts such as a lawn mower or an air-conditioning or refrigeration compressor. (Note: Have a serviceman first discharge the refrigerator safely)
B. Mechanical 1. Bearings 2. Belts and Chains 3. Cams 4. Clutches 5. Gears 6. Levers/mechanical 7. Pulleys 8. Shafts/axles 9. Springs -	- Have the students analyze a common energy/power transmission system. A good example in rural communities is a combine. Have them identify as many types of mechanical power transmission components as possible. - Assign a project to construct a working clock from paper. (Edmund Scientific) - Have the students design and build a simple vending machine. The activity could include the disassembly of an old vending machine for analysis by the students. Emphasize the relationships between components. - Radio shack has a Mechanical Lab Kit which contains thirty projects such as a drawbridge, a differential, a clock, and more. The kit contains a variety of gears, pulleys, levers, etc.
C. Electrical 1. DC 2. AC 3. RF	- Conduct a problem-solving design activity where students use a salvaged stepper motor in the construction of a working system. Possibilities for systems include a series of gears and levers for using mechanical advantage to lift a very heavy object, a mechanized display for a school holiday, a crusher mechanism for trash or pop cans. Another possibility would be to interface the device with a computer. Radio frequency control could also be added.
III. Measurement A. Units 1. Force -Metric -Newtons -Customary -Pounds	- Develop a worksheet requiring students to research the meaning of customary and metric measurement units. - Have students calculate conversions between metric and customary units for power related units of measure.

Student Activities

- Design and construct a working one-way fluid valve. Test with water to see if it will actually work.
- Add a feedback loop to the fluid valve that you have constructed. Design it to interface with a temperature sensing mechanism such that the flow is regulated by temperature changes.
- Make a cut-a-way model of an automobile water pump. Paint the various parts to a color code. Develop labels and put on display.
- Identify as many different types of power system components as you can in your automobile. Examples of power system components include cylinders, flow controls, valves, and regulators.
- Recondition and repair a car clutch or transmission.
- Identify as many mechanical power transmission devices and types as you can in your energy and power laboratory.
- Run a series of tests on a model rocket. What engine configurations achieve the greatest altitude? How do various design factors contribute to stability? Describe the interrelationship between stability, thrust, velocity and altitude. Pay particular attention to safety concerns and guidelines.
- Go to a facility which has an NC machine. Carefully examine the motors and controls that provide movement in the various directions. Draw a diagram that shows how the various components relate to one another.
- In groups, select an issue, phase, controversy, etc which occurred in history related to the development of measurement systems. Examples could include research into how measurement systems got started; an incident in which measurement or mis-measurement may have led to embarrassment, injury, or war; historical sketches of persons responsible for the development of measurement systems, etc.

Resources & References

- Meys, J. "Add Robotics Without Much Expense." The Technology Teacher, February, 1988, pp. 25-28.
  [Section III - Part 2, Periodicals/ Magazines]
- Neddenriep, T. "Construct a robot simulator for use in the general shop" School Shop, October, 1987, pp. 20-21.
  [Section III - Part 2, Periodicals/ Magazines]
- Schwaller, A. "What Is a robot anyway?" School Shop, September, 1985, pp. 27-29
  [Section III - Part 2, Periodicals/ Magazines]
- Gemini Educational Systems
  [Section III - Part 5, Resource Centers]
- Edmund Scientific
  [Section III - Part 6, Sample Suppliers]
- Physics software. Apple II program available from Pitsco.
  [Section III - Part 8, Software]
- Stephensen, G. E. Power technology.
  [Section III - Part 1, Books & Resources]
- MAVCC - Exploring Technology Education. Power Transmission and Control: Section E-3, MVRC
  [Section III - Part 1, Books and Resources]
- AstroCad. Apple II software for performance analysis of model rockets. Available from Pitsco.
  [Section III - Part 8, Software]
- Flight. Apple II software for performance analysis of model rockets. Available from Pitsco.
  [Section III - Part 8, Software]
- Principles of Technology video series. MVRC
  [Section III - Part 4, Media Sources]
- MAVCC - Exploring Technology Education. Energy and power conversion/measurement: Section E-2, MVRC
  [Section III - Part 1, Books and Resources]

Content

2. Work
    - Metric
    - Joules
    - Customary
    - Foot-pounds
3. Mechanical
    - Metric
    - Watts
    - Customary
    - Horsepower
4. Pressure
    - Metric
    - Pascals
    - Customary
    - Pounds per square inch
5. Torque
    - Metric
    - Newton-meters
    - Customary
    - Pound-feet

B. Apparatus
  1. Thermometers
  2. Dynamometers
      - Prony brake
      - Hydraulic
      - Electric
  3. Calorimeters
  4. Watt meters

C. Techniques
  1. Dynotesting
  2. Energy consumption
  3. Temperature change
  4. Wattmeters
  5. Calculation

IV. Power Conversion

A. System Conversions
  1. Fluid/Mechanical
      - Actuators
      - Fluid motors
  2. Electrical/Mechanical
  3. Mechanical/Mechanical
  4. Fluid/Electrical

B. Changes in Direction/Motion
  1. Reversing
  2. Rotation
  3. Motion type conversions
      - Reciprocating
      - Continuous/Intermittent
  4. Linear

C. Speed and Force Changes
  1. Mechanical Advantage
  2. Rate

Teacher Plans & Activities

- Have each student prepare a conversion chart as a visual aid for display and instructional purposes.
- Assign a report/presentation to see what interesting historical information students can uncover related to measurement systems.
- Lead a discussion of the advantages and disadvantages of the customary and metric systems.
- Arrange for a demonstration on a variety of measurement devices including a dynamometer, wattmeter, prony brake, etc. Stress the importance of safety related to these devices. Many of they can be extremely dangerous.
- Arrange for a field trip to a facility that rebuilds and tests the power output of large diesel engines. Farm implement or commercial trucking service facilities are excellent resources.
- Brainstorm various types of power system conversions. Examples could include hydroelectric generators, engine driven electrical generators, etc.
- Have the students design and build a reciprocating device from a rotating device. The device could be operated by hand or mechanically. An example is the movement of a connecting rod in an automobile engine.

Student Activities

- Make a poster which shows the various aspects of power. For example, a tractor could be used to depict mechanical power. Develop equivalent customary and metric unit values that could apply to the pictures.
- Use a dynamometer to measure the power output of a gasoline-powered engine. Pay particular attention to safety concerns before operating the equipment.
- Disassemble, repair and rebuild a small gasoline engine.
- Disassemble and reassemble a Cox.049 Baby Bee engine.
- Design and build a prototype hot air balloon. Critical design challenges and concepts are lifting power, endurance, and directional control.
- Compile a listing of power conversion devices found on a farm. Examples could include conveyors, augers, PTOs, etc. For each type of device identify the system conversion (e.g., from fluid to mechanical) and/or the direction/change motion conversion (e.g., rotating to reciprocating). In addition, identify the important safety considerations related to each of the devices.
- Make a mousetrap vehicle.
- Design and build a variable speed device for a rotating device. Test the power output at various speeds. What relationship exists between momentum, speed, lugging ability, etc?
- Have students construct gear sets, cams, crank and connecting rods and the like out of clear and colored plexiglass for displays on the overhead projector.

Resources & References

- Power Engineering.
  [Section III - Part 2, Periodicals/ Magazines]
- American Public Power Association
  [Section III - Part 7, Associations/ Organizations]
- Maughan, G. The way things work.
  [Section III - Part 1, Books & Resources]
- Cox.049 engine. Pitsco.
  [Part 6, Sample Suppliers]
- Kaiser, J. Electrical power, motors, controls, generators, & transistors.
  [Section III - Part 1, Books & Resources]
- Natural Association of Power Engineers
  [Section III - Part 7, Associations/ Organizations]
- Jet Propulsion Laboratory
  [Section III - Part 5, Resource Centers, Sample Suppliers]
- Vernier Software
  [Section III - Part 8, Software]
- TAM #8: Internal Combustion.
  [Section II - Missouri Introduction to E&P Guide]
- Roth, A. C. & Baird, R.J. Small gas engines: 2 cycle & 4 cycle engines.
  [Section III - Part 1, Books & Resources]
- Gears Computer program. Pitsco.
  [Section III - Part 8, Software]
- TAM #10: Fundamentals of Mechanical Power Transmission.
  [Section II - Missouri Introduction to E&P Guide]
- TAM #5: Energy Conversions.
  [Section II - Missouri Introduction to E&P Guide]
- Yates, M. Earth power.
  [Section III - Part 1, Books & Resources]
- Freeman, I. M. Physics made simple.
  [Section III - Part 1, Books & Resources]
- Hewitt, P. E. Conceptual physics.
  [Section III - Part 1, Books & Resources]
- Marcus, A. Introduction to applied physics.
  [Section III - Part 1, Books & Resources]

Missouri

Introduction to Energy & Power Technology

Unit 4: Power Fundamentals - Transfer & Utilization

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

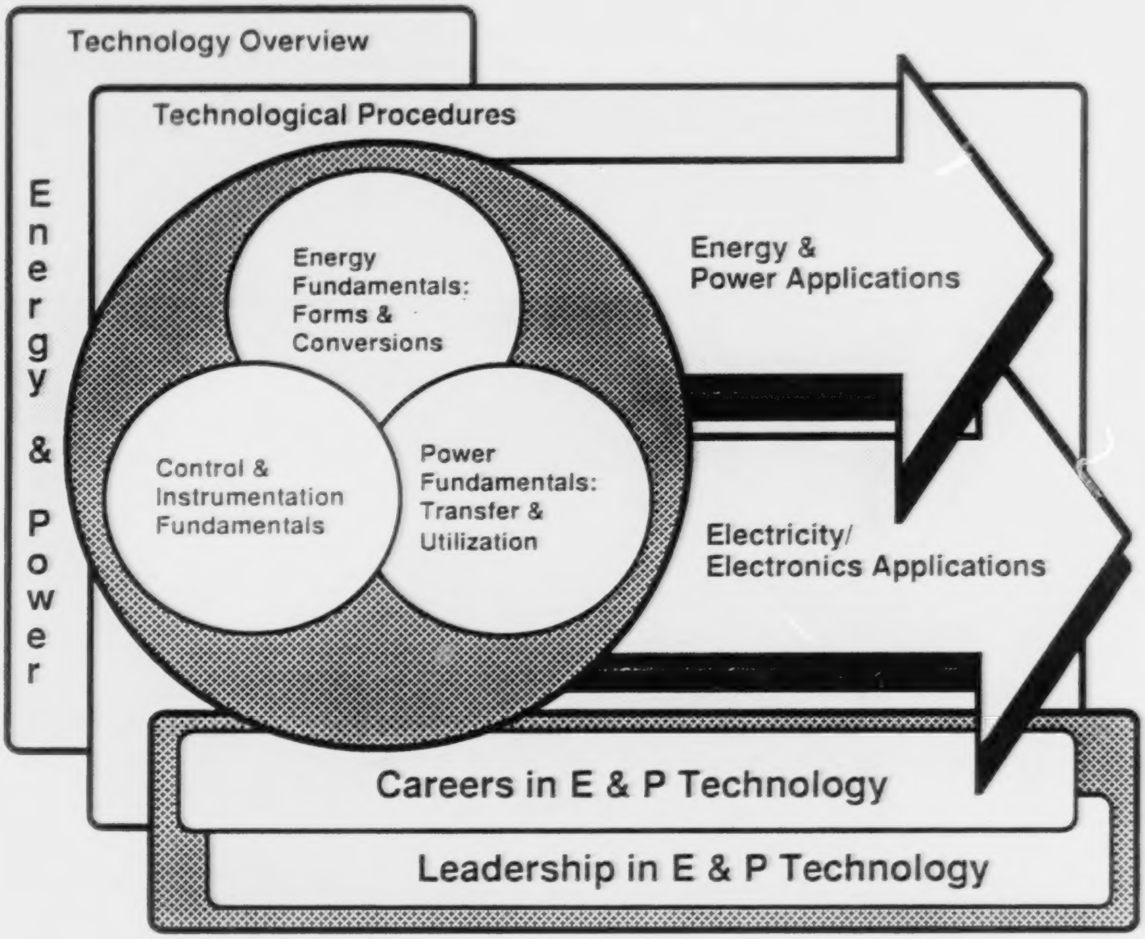
Advisory Council Input:

Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 5: Control & Instrumentation Fundamentals


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Five: Instrumentation & Control Fundamentals

OBJECTIVES: The purpose of this unit is to examine the fundamentals of instrumentation and control including components, systems configurations, basic types, and ergonomic considerations.

COMPETENCIES -- The student will be able to:

1. Identify and describe the major components of instrumentation & control systems such as: sensors, transducers, regulators, final control elements, regulators, indicators and computers. (5,I)
2. Explain how various sensors work. (5,I)
3. Develop and install instrumentation & control systems on laboratory energy & power systems. (5,I)
4. Sketch the configuration of instrumentation & control systems designed to meet assigned needs. (5,II)
5. Learn how to develop flow charts including inputs and outputs. (5,II)
6. Explain the concepts of positive and negative feedback. (5,II)
7. Use the computer to control systems. (5,II)
8. Select appropriate instrumentation based on the information to be communicated. (5,III)
9. Differentiate among the types of instrumentation & control systems: fluid, optical, mechanical, electrical, electronic, and electro-mechanical, and identify appropriate applications of each. (5,III)
10. Display system operation information on the computer. (5,IV)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

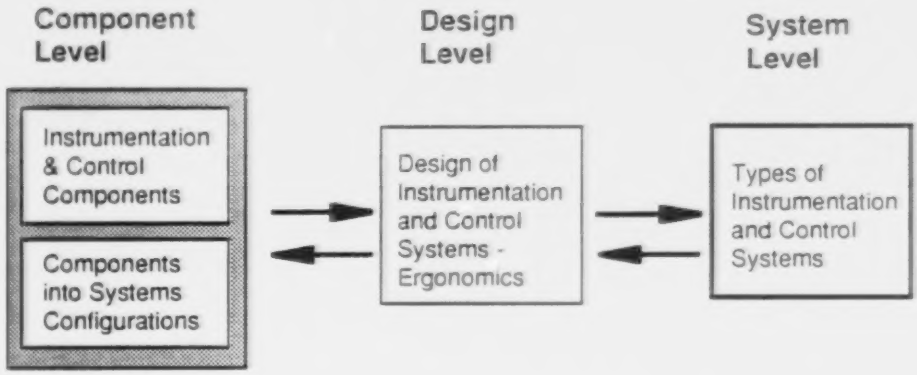
Content

I. Instrumentation & Control Components
   - A. Actuators
   - B. Indicators
   - C. Microprocessors
   - D. Regulators
   - E. Relays
   - F. Sensors
   - G. Controllers
   - H. Servo-mechanisms
   - I. Servo-systems
   - J. Solenoids
   - K. Switches
   - L. Timers
   - M. Transducers

Teacher Plans & Activities

- Develop a worksheet requiring students to identify examples of actual applications of instrumentation and control components. Make certain that the terms are understood and defined.
- Arrange for students to tour the "boiler room" of your school. Identify and discuss the function of the various components and subcomponents found in the system. Encourage them to think the system through on the basis of their current level of knowledge before giving your input. Also, identify some of the critical safety factors related to the system.
- Demonstrate some common sensor types and typical applications.
- Use strain gauges or some other instrument-based non-destructive testing system to demonstrate NDT on materials.
- Have students salvage instrumentation and control components from sources such as discarded home appliances, wrecked automobiles, old machines, etc. These could include a wide variety of servo-mechanisms, switches, solenoids, gauges, regulators, etc. Use these to develop a working display or to build a functional control and feedback device.
- Have students go to a wrecking yard to obtain a screw motor mechanism from an automobile power seat. Use the component to construct a device for bridge testing.

Lesson/Activity Outline


Component Level
Instrumentation & Control Components
Components into Systems Configurations
Design Level
Design of Instrumentation and Control Systems - Ergonomics
System Level
Types of Instrumentation and Control Systems

Student Activities

- Design and construct a sensor controlled device which will automatically feed your dog while you are on vacation. How will you insure the safety of the device?
- Design a sensor/feedback system which can monitor and control a greenhouse. Control for humidity and temperature variables.
- Think of a problem that you have in your everyday life. This could be with something not working, an inconvenience, an irritation, etc. Once you define the problem design a device to solve the problem using an instrumentation and control mechanism.
- Build relays and hook them together for control. An example is a latching relay (saw switch) and logic gates (keyless entry). Pay particular attention to electrical safety guidelines.
- Design a sensor mechanism that is capable of detecting low fluid levels in your car's radiator or windshield washer reservoir.
- Design a car seat and console mock-up for comfort and ease. Then actually power up one or more of the controls.

Resources & References

- Gateway Electronics (good supplier for stepper motors)
  [Section III - Part 6, Sample Suppliers]
- Popular Electronics
  [Section III - Part 2, Periodicals/ Magazines]
- How to build a better mouse trap.
  Vernier Software
  [Section III - Part 8, Software]
- Chaney Electronics
  [Section III - Part 6, Sample Suppliers]
- Gemini Education Systems
  [Section III - Part 5, Resource Centers]
- AIT Video. Exploring Technology Education. Transmission, Control, and Storage of Power: Section E-3, MVRC
  [Section III - Part 4, Media Sources]
- EKI (information related to relays, sensor, and other electronic components)
  [Section III - Part 6, Sample Suppliers]
- Unilab Inc. (supplier for controllers for robotic devices)
  [Section III - Part 6, Sample Suppliers]

Content

II. Systems Configurations
  - A. Closed Loops
  - B. Open Systems
  - C. Factors Controlled
    - 1. Flow
      - -Volume
      - -Speed
    - 2. Temperature
    - 3. Pressure
    - 4. Rate of change

III. Types of Instrumentation & Control Systems
  - A. Electrical
    - 1. Meters - analog
    - 2. Meters - digital
  - B. Electro/Mechanical
    - 1. Meters
    - 2. Scales
  - C. Electronic
    - 1. Meters
  - D. Fluid
    - 1. Pressure valves
    - 2. Flow valves
    - 3. Gauges
  - E. Magnetic
    - 1. Meters
  - F. Mechanical
    - 1. Scales
  - G. Optical
    - 1. Photo cells

IV. Ergonomics
  - A. Visual Factors
  - B. Auditory Factors
  - C. Tactile Factors
  - D. Olfactory Factors
  - E. General Human-Machine Interface

Teacher Plans & Activities

- Propose an activity where the students are to design a futuristic control and instrumentation system for a house they will live in one day. Encourage them to be creative and innovative.

- As a follow-up, have them identify systems components such as feedback mechanisms, control devices, data monitoring and display devices, etc. Again, they need not be able to actually construct the system. The focus is on an understanding of the TYPE of component and system configuration that would be necessary for the system to function properly.

- Demonstrate stepper and servo motors. Have students distinguish between the two.

- Conduct a session where students analyze the heating and air-conditioning system's feedback mechanisms. Emphasize both the identification of components and the function of components in the system.

- Use an instructional robot to demonstrate a servo motor (closed loop control).

- Have a competition using radio frequency control of a mechanism that students could build and then operate. Examples could include model cars, model planes, model boats, garage door openers, etc.

- Have students trace the development of controls and instrumentation from their early applications in industry through the computer age.

- Have the students black box analyze the valve and gauge system in an oxyacetylene torch.

- Have the students use a strain gauge to measure a variety of force situations.

- Ask the students to speculate on how a photo-cell activated automatic door opener operates.

- Assign students an instrumentation system to analyze. Examples could include an automobile, tractor, stereo system, etc. Encourage a solid critique of the quality of the system from an ergonomic point of view. Is it easily read? Does it convey information quickly and accurately? What alternatives would improve the system?

- Analyze a color organ's output. Discuss the relationship among sound wave transmission, electronic sensing, and visual display.

Student Activities

- Develop a digital schematic for a burglar/fire alarm combination for your house. Specify the output type, such as LED, auditory alarm, etc.
- Create a flow chart for an automatic garage door opener. Use the appropriate graphic shapes throughout.
- Design a closed loop feedback system for monitoring the rate of fluid flow. An example could include a monitoring/control device to regulate the rate of flow for a liquid fertilizer in an agricultural application. You will need to consider factors such as how to monitor the change in fluid level, how to adjust flow rate in response to feedback, etc.
- Build a working system using a fluid power trainer and then control it by means of an operating control system. Analyze the advantages of fluid versus electronic control systems.
- Design and construct a clock that is controlled by a computer.
- Analyze a toilet bowl fluid level control mechanism. How does it work? What parts serve as feedback mechanisms? What parts provide the control? How would you improve the system?
- Build a noise monitoring system. Turn your stereo system to the volume where you normally listen to it. Record the results. Compare these with output obtained from other sources such as the dust collector in the woods technology laboratory, the siren of a police car, etc.
- Provide examples of the displays that are most effective as visual displays (such as gauges, blinking lights, indicator lights, numerical displays, etc.), sound output (such as buzzers, sirens, etc.), touch output (such as heat emission), and smell output (such as natural gas additives). List specific examples of situations where they are used. Why are the display/outputs best suited for those situations? Are they the best output or would other methods be preferred?
- Construct an electronics kit which uses sensors, operates as a control device, or uses effective display indicators.

Resources & References

- Vishay Engineering (supplier for strain gauge materials)
  [Section III - Part 6, Sample Suppliers]
- Technovate (supplier for strain gauge equipment and supplies)
  [Section III - Part 6, Sample Suppliers]
- TAM #12: Instrumentation & Control Revealed.
  [Section II - Missouri Introduction to E&P Guide]
- TAM #18: Using Electronic Instrumentation.
  [Section II - Missouri Introduction to E&P Guide]
- 160-N-ONE kit from Radio Shack
  [Section III - Part 6, Sample Suppliers]
- Lego Education Division
  [Section III - Part 6, Sample Suppliers]
- Kelvin Electronics
  [Section III - Part 6, Sample Suppliers]
- Heathkit/Zenith Educational Systems
  [Section III - Part 6, Sample Suppliers]
- Hinterseher, F. Holography handbook.
  [Section III - Part 1, Books & Resources]
- Salant, M. A. Introduction to robotics.
  [Section III - Part 1, Books & Resources]
- Potter, T & Guild, Inc. Robotics.
  [Section III - Part 1, Books & Resources]
- McComb, G. The robot builder's bonanza.
  [Section III - Part 1, Books & Resources]
- Muller, F. Basic robotics curriculum guide.
  [Section III - Part 1, Books & Resources]
- Graymark
  [Section III - Part 6, Sample Suppliers]
- Unilab
  [Section III - Part 6, Sample Suppliers]
- Vernier Software
  [Section III - Part 8, Software]

Missouri

Introduction to Energy & Power Technology

Unit 5: Control & Instrumentation Fundamentals

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

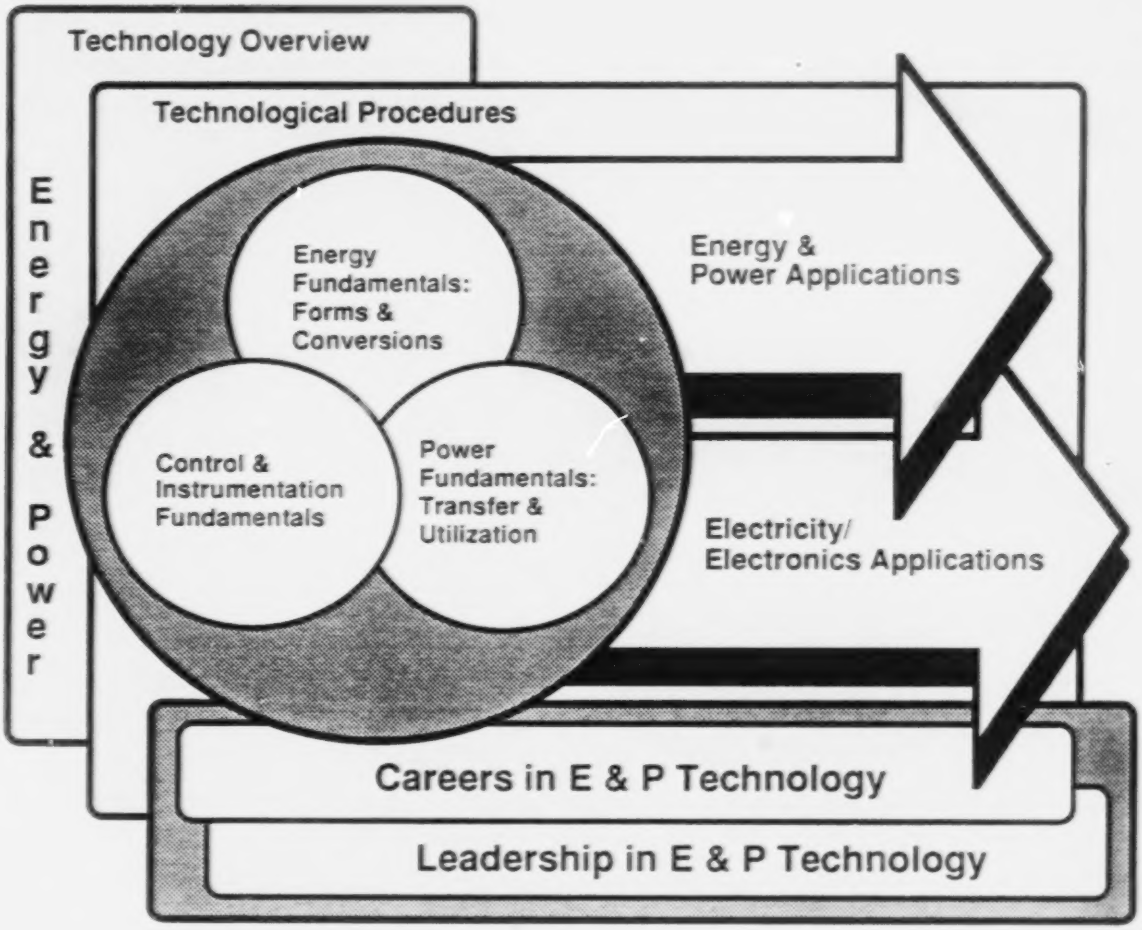
Advisory Council Input:

Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 6: Energy & Power Technology Applications


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Six: Energy & Power Technology Applications

OBJECTIVE: The purpose of this unit is to focus essential applications in Energy & Power technology including transportation, materials and processing, and communication. Ethical, economic and environmental implications will also be discussed.

COMPETENCIES -- The student will be able to:

1. Describe the functions of transportation systems in the movement of goods and people. (6,I)
2. Describe the components of transportation systems. (6,I)
3. Compare and contrast the advantages and disadvantages of various forms of engines for particular applications. (6,I)
4. Summarize rules and regulations which control transportation. (6,I)
5. Project alternative futures for current transportation system. (6,I)
6. Read and interpret transportation system maps, charts, and schedules. (6,I)
7. Explain the support systems which serve the transportation enterprise. (6,I)
8. Describe the safety aspects of transporting goods and people. (6,I)
9. Describe the major developments and steps that enabled space transportation. (6,I)
10. Describe the evolution of various types of transportation systems such as terrestrial, air, water and space. (6,I)
11. Identify the applications of energy and power technology in the propulsion, payload and guidance systems used in spacecrafts. (6,I)
12. Demonstrate proper safety precautions in working with model rockets. (6,I)
13. State the advantages and limitations of various modes of material and/or people transportation systems such as railroads, automobiles, robots, mass transit, pipelines. (6,I)
14. Identify the key categories of service involved in maintaining energy & power equipment. (6,II)
15. State how robots are examples of energy and power technology as well as materials handling technology. (6,II)
16. Construct robots that apply energy and power technology in a controlled manner. (6,II)
17. Analyze industrial equipment operation in terms of energy conversion, power transmission, and instrumentation & control systems. (6,II)
18. Transfer information directly between two computers. (6,III)
19. Experiment with processes, equipment, and materials to develop insight into new and advancing energy & power technologies. (6,III)
20. Describe examples of applications in environmental control. (6,IV)
21. Discuss applications of energy and power in areas such as medicine, agriculture, and the military. (6,V)
22. Describe examples of large scale power distribution systems. (6,VI)
23. Explain the pollution problems posed by the use of various transportation systems. (6,VII)
24. Discuss ethical issues related to environmentalism, pollution, military surveillance, etc. (6,VII)
25. Identify and discuss key economic factors related to energy and power applications, e.g. cost, scarcity, availability, etc. (6, VIII)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Applications in Transportation

  A. Modes
    1. Land/Terrestrial
      a. Fixed
        -train
        -subways
      b. Random
        -auto
        -truck
        -recreational vehicle
        -agricultural vehicle
        -construction vehicle

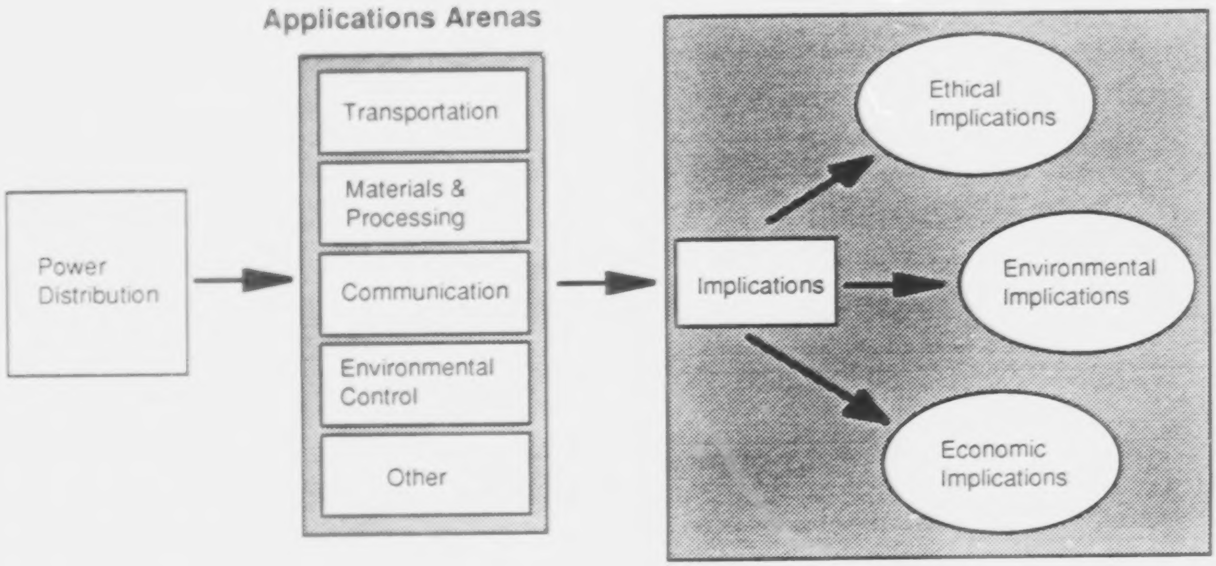
Teacher Plans & Activities

- Have the students design and build a small scale solar vehicle. Set up a contest to compare the effectiveness of the various designs.

- Have students think through design possibilities and safety considerations for a levitating train.

- Prepare presentations on internal combustion engines.

- Arrange for a field trip to a site where varied, interesting, or large numbers of transportation devices are used. Examples could include an assembly plant, an earth-moving company, etc.


Applications Arenas
Power Distribution
Transportation
Materials & Processing
Communication
Environmental Control
Other
Implications
Ethical Implications
Environmental Implications
Economic Implications

Student Activities

- Design and build a simulated pipe line to deliver liquid by syringes and plastic hose.
- Design and build a robot arm. Set up a contest to dunk an egg, lift a weight, etc.
- Working in groups, compete to see who can think of the highest number of examples of common pipeline transportation systems. Examples include a dust collection system, the water distribution system in your house, the city's sewage system, etc.

Resources & References

- How to make computer controlled robots. Pitsco
  [Section III - Part 6, Sample Suppliers]
- Winter, W. The world of model airplanes.
  [Section III - Part 1, Books & Resources]
- Smith, H. The illustrated guide of aerodynamics. Available from Trans-Tech.
  [Section III - Part 1, Books & Resources]

Content

- c. Stationary
  - -pipeline
  - -conveyors
  - -elevators
  - -chutes
  - -wire guides

2. Air/Atmospheric
   - a. Heavier than air
     - -planes
     - -jets
     - -helicopters
     - -gliders
   - b. Lighter than air
     - -balloons
     - -blimps
   - c. Forces that act on air vehicles
     - -drag
     - -lift
     - -thrust
     - -gravity

3. Marine/water
   - a. Ships
   - b. Sail boats
   - c. Submarines
   - d. Recreational craft
   - e. Exploratory craft

4. Space
   - a. Rocketry
     - -liquid
     - -solid fuels
   - b. Space stations
   - c. Space vehicles/lunar modules
   - d. Satellites
   - e. Applications
     - -Technological advancement
     - -Planetary Exploration
     - -Scientific experimentation
     - -Defense superiority

Teacher Plans & Activities

- Have the students debate the value of the Alaskan pipeline. Present arguments pro and con on using pipeline transportation over other means? Include a discussion of factors such as ecology, economics, etc.

- Invite a zoologist or a member of the school's science faculty to speak to the class about what scientists know about why birds fly. Encourage questions such as advantages birds have over mechanical flight mechanisms, why they don't seem to get tired in migratory flight, etc.

- Have the students make a collage of a variety of flight-related photos. Build in some old pictures such as those of early failures, Howard Hughes Spruce Goose, etc.

- Arrange for a demonstration of a hot air balloon. Provide time for the owner to talk about the theory, practices, techniques involved in balloon flight. Make sure to include discussion of safety considerations related to hot air balloons. What kinds of mistakes are commonly made that could make the sport dangerous?

- Spend some classroom time outlining the safety issues related to transportation systems. Often students become so absorbed in making things go that they overlook the safety implications.

- Pose the question: "Why do rocks sink while ships, weighing tons, float?" Have students test a number of different types of materials to see which have the best floatation characteristics.

- Lead a discussion over how the principles related to flight are applied to sailing and sail design and configuration.

- Conduct a brainstorming session of features that would need to be included in space station. You will need to think through systems such as propulsion, communication, utilities, recreation, human needs (food, waste, hygiene), etc.

- Have students analyze the effects of aerodynamics in design on cars, ships, and planes using a wind tunnel.

Student Activities

- Design and build a bank teller capsule type of pipeline system.
- Design, construct, fly and measure the performance of a water powered rocket.
- Build a wind tunnel for testing the aerodynamics of a variety of wind related items. Design, construct and test different shapes of aircraft wings for coefficient of drag and lift capabilities. Keep accurate documentation of the test results.
- Create a railroad system utilizing a model railroad set.
- Design and construct a model airplane. This could be out of Styrofoam, wood, paper, etc. Pay close attention to aerodynamic factors such as wing design, weight, balance, etc. Have a flying contest to see who's plane stays airborne the longest, which flies the straightest, or some other standard. At the completion of the competition have a class debriefing session to determine which factors were most important. Write a short paper presenting some aspect of your findings.
- Make a flight video. Include as many flight related images as you can. Edit and set the video to music. This could be incorporated into an all-school presentation.
- Go to the local airport. Have a person who is in charge of aircraft and/or airport maintenance explain procedures that are routine/critical to safe flight.
- Design and build a mousetrap powered boat.
- Work through a design for a vehicle which will work in both water and on land. Build a model.
- Conduct experimentation with various boat shape designs. These could be made of wood, Styrofoam, etc. Test the shapes for features such as stability, speed, maneuverability, etc. As a part of the design process consult sources such as books, articles, knowledgeable persons, etc.
- Use a CAD system to draw a 3D design for a lunar land based vehicle

Resources & References

- Siuru, W. & Busick, J. D. Future flight: The next generation of aircraft technology. Available from Trans-Tech. [Section III - Part 1, Books & Resources]
- Boyer, P. M. Unconventional aircraft. Available from Trans-Tech. [Section III - Part 1, Books & Resources]
- Chuck Yeager's Advanced Flight Trainer (Apple, IBM, Macintosh) [Section III - Part 8, Software]
- Hughes, L. R. Transportation systems. [Section III - Part 1, Books & Resources]
- Test drive and Test drive II (Accolade software). Apple and IBM. [Section III - Part 8, Software]
- Ford simulator and Ford simulator II IBM and Macintosh software. [Section III - Part 8, Software]
- Jeep simulator. Public domain software. IBM [Section III - Part 8, Software]
- Sunracer Public domain software. Apple. [Section III - Part 8, Software]
- Cessna Aircraft Corporation [Section III - Part 5, Resource Centers, Sample Suppliers]
- Whitewings. Available from Transtech [Section III - Part 6, Sample Suppliers]
- Flight Simulator. Microsoft Corporation [Section III - Part 8, Software]
- Glide Path. Apple software available from Creative Learning Systems Inc. [Section III - Part 8, Software]
- Jet Propulsion Laboratory (Space and solar information) [Section III - Part 5, Resource Centers]
- Boat hull design. Theta Industrial Products, P.O. Box 70 S-1, Mound, MN 55364 [Section III - Part 6, Sample Suppliers]
- Flight Simulator II (Apple software). Available from Sub Logic Corporation [Section III - Part 6, Sample Suppliers]

Content	Teacher Plans & Activities
B. Vehicle Subsystems 1. Propulsion a. Engine types -Internal Combustion -Two cycle -Four cycle -Rotary b. Drive mechanisms c. Conversion/Transmission	- Explain and illustrate the differences between different engine configurations, e.g. rotary, opposed, turbine, diesel, two cycle, four cycle, etc. - Take the students on a field trip to an automotive machine shop. If possible arrange to see crankshaft grinding, valve and head work, cylinder boring, and dynamic engine balancing. Encourage them to be alert to any safety concerns that they might spot in the shop. - Promote student attendance at an antique engine show. Many shows combine displays of old threshing machines, stationary engines, steam engines, etc.
2. Structure a. Frame/body b. Hull c. Fuselage	- Obtain the computer software, Car Builder. Have the students test a number of different designs. Use the program as a way of stimulating discussion related to the importance of factors such as weight, coefficient of drag, weight distribution, wheel base, etc. - Obtain a donation of a running automobile from a salvage yard. Conduct a series of tests for acceleration or gasoline mileage. Do this by the systematic removal of weight. First, remove components that are detachable. Proceed systematically until body parts must be torched off. Maintain accurate records of systematic weight reduction and of corresponding changes in performance. Debrief the experience. - An excellent follow-up exercise is to have the students present their experience and learning to an all school convocation. In anticipation of this, it would be good to record activities on video.
3. Suspension a. Wheels b. Wings c. Track/rail d. Air cushion e. Hydro foils	- Assign the students a design problem. Have them think through the development of a hover craft/air cushion vehicle. Problems needing resolution could include the source of power supply, stability, and lifting specifications.
4. Guidance and control a. Vehicular controls -On-off -Direction, force, and speed b. System controls -On-off -Direction, force, and speed	- Have the students black box analyze a cruise control system. Have them develop a graphic which depicts the components necessary to make the system work.

Student Activities

- Run the Flight Simulator II software package on the computer.
- Do a report on a rocket-powered dragster. Include as much design, testing, and safety information as you can find. Include photos, specification sheets, etc.
- Do an overhaul of a small gasoline engine. Be certain to observe all safety precautions.
- Build a demonstration cutaway model of a small gasoline engine. Color code the various components.
- Visit an automotive body shop which is equipped with laser body alignment equipment. View a demonstration on how the system works. Inquire about the special safety precautions which must be observated when using lasers.
- After viewing a commercial laser alignment system, design and build a simplified demonstration unit that can conduct simple measurements.
- Analyze pictures of car body styles over the past 30-40 years. What kinds of changes can you identify that appear to be the direct result of the concern for aerodynamics for fuel savings? Identify specific features and/or changes
- Locate some old comic books that contain some future-oriented material, e.g. space. Check with your parents, a friend's parents, or some other source. Try to locate some 40 years or so old. How similar or different are current designs to those depicted years ago? How are some current designs improvements over early imaginations?
- Obtain materials from NASA which describe how rocket control systems work.
- Visit an airport control tower. If one is not available go to a small, local airport. Question a pilot, controller, maintenance persons, etc. about the mechanisms involved in airline radar, navigation, guidance, and control.
- Do a short report of the history of railroad development in the U.S.

Resources & References

- Oak Ridge National Laboratory
  [Section III - Part 5, Resource Centers]
- TAM #8: Internal Combustion
  [Section II - Missouri Introduction to E&P Guide]
- TAM #10: Fundamentals of Mechanical Power.
  [Section II - Missouri Introduction to E&P Guide]
- Roth, A. C. & Baird, R. J. Small gas engines.
  [Section III - Part 1, Books & Resources]
- Briggs & Stratton
  [Section III - Part 6, Sample Suppliers]
- AIT Video. Exploring Technology Education. Conversion of Energy into Power: Section E-2, MVRC
  [Section III - Part 4, Media Sources]
- Car Builder (Apple Software)
  [Section III - Part 8, Software]
- Chaney Electronics (supplier for simulated laser)
  [Section III - Part 6, Sample Suppliers]
- Hot Rod
  [Section III - Part 2, Periodicals/ Magazines]
- Orbiter. Software for the IBM and Macintosh. Space Shuttle Simulation. Spectrum Holobyte, Inc.
  [Section III - Part 8, Software]
- Rocket Kits from Estes Industries.
  [Section III - Part 6, Sample Suppliers]
- Futurist
  [Section III - Part 2, Periodicals/ Magazines]
- Popular Science
  [Section III - Part 2, Periodicals/ Magazines]
- NASA
  [Section III - Part 5, Resource Centers]
- In search of space: Physics of model rocketry. Estes Rocketry software
  [Section III - Part 8, Software]

Content	**Teacher Plans & Activities**
c. Guidance systems -Physical guideways -highways -railways -tubes -waterways/canals -cables -On-board guidance systems -radios -speedometers -radar -gauges -sensors -computers	- Invite someone in your community who has an historical interest in highway development. An informed and interesting speaker can present information about how early routes were chosen, how roads and bridges were built to accommodate vehicles of the day, interesting failures, etc.
d. External guidance systems -traffic lights -signs -navigation markers -signals -radar -computers	- Arrange for a policeman to demonstrate radar equipment. Explain the theory of how radar works, its limitations, etc. - Arrange for a serviceperson familiar with traffic control signal devices to give a demonstration to the class. Focus primarily on how the devices work. What particular precautions do they take related to traffic safety, e.g. back-up systems.
II. Applications in Material Processing A. Maintenance 1. Electrical systems 2. Mechanical systems 3. Fluid systems	- Have students analyze a device or an appliance such as a washing machine, dishwasher, stove, table saw, electric break meter, etc. Have the students determine the points that need maintenance such as lubrication, part replacement, cleaning, etc. Have them develop a maintenance chart similar to those used for automobile warranties.
B. Equipment Operations/Production 1. Components & systems -Robots -servo -stepper -Controls -Sensors -Instrumentation/control -CNC -NC -Clamping systems	- Arrange for the students to see a demonstration of a computerized manufacturing simulation program. - Take a field trip to a manufacturing facility which is using computer integrated process. - Contact the extension service of a university to explore possibilities of having a person from engineering or Industrial Technology Education come to the school for a demonstration and/or presentation of E&P related computer integrated manufacturing technology. This could be a cooperative project between science and ITE departments.
2. Supply & conversion factors -Energy sources -Power conversion\ -Control system -Position rate -Sensitivity	

Student Activities

- Develop a design for a computerized control system for a van. Include capabilities for the following typical kinds of functions: cruise control, odometer, tripometer, gasoline mileage, estimated time of arrival, etc. Include some new features such as an automatic alcohol detection ignition kill switching device, a snooze detector/alarm, alpha brain wave radio station control, etc. Specify the kinds of sensors, components, computing capability, etc that would be necessary to develop the system.
- Design and construct a radio or telephone system.
- Construct a robot using Robotix and then control it with the computer.
- Design and construct a manufacturing system model utilizing mechanical, fluid, and electrical power transmission/control devices.
- Design, construct, and operate a syringe robot. Speculate as to how robots could be "trained" to recognize positions, voices, pressure, light, or other input data.
- Identify particular safety concerns related to robots. Why are they so dangerous? What kinds of devices are built into robots by manufacturers to protect workers?
- Design and construct an model telegraph system.
- Utilize a laser, receiver, and fiber optics in an experiment involving the sending of messages. Be certain to pay attention to the safety hazards of using lasers.

Resources & References

- GM sunracer: Solar powered vehicle. Available from General Motors Corporation. 20 minute video and Apple program (free of charge).
  [Section III - Part 4, Media Centers]
- Three good pamphlets.
  Fluid power
  Moving goods and people on land
  Moving goods and people through space
  Available from Theta Industrial Products, P.O. Box 70, Mound, MN 55364
  [Section III - Part 4, Media Centers]
- DeOld, A. Sheets, E. & Alexander, W. Transportation: The technology of moving people & products.
  [Section III - Part 1, Books & Resources]
- See Book Index in the Resources section of the guide for a number of excellent sources on Robotics.
  [Section III - Part 1, Books & Resources]
- Robotix (Milton Bradley) available from Pitsco.
  [Section III - Part 6, Sample Suppliers]
- Berger, P. The state-of-the-art robot catalog.
  [Section III - Part 1, Books & Resources]
- Robot assembly lab
  [Section III - Part 8, Software]
- Robcat (Apple software)
  [Section III - Part 8, Software]
- Salant, Michael. Introduction to robotics.
  [Section III - Part 1, Books & Resources]
- Marsh, Peter. Robots.
  [Section III - Part 1, Books & Resources]
- Power grid. HRM Software for the Apple Computer.
  [Section III - Part 8, Software]
- Heathkit/Zenith Educational Systems
  [Section III - Part 6, Sample Suppliers]
- MAVCC - Exploring Technology Education. Energy, Power & Transportation: Section C, MVRC
  [Section III - Part 1, Books and Resources]

Content	Teacher Plans & Activities
III. Applications in Communications A. Integrated Systems Control B. Power Systems Monitoring C. Satellites D. Weather Monitoring E. Surveillance F. Fiber Optics/Lasers	- Locate an old mechanical calculator. Have students take it apart to figure out how it works.
IV. Applications in Environmental Control A. Heating B. Air Conditioning C. Ventilation	- Look into the possibility of obtaining programs such as "Weather Station" which provide on-line computer managed information, in this case weather information.
V. Other Applications Areas A. Medicine B. Military C. Agriculture	
VI. Power Distribution A. Electrical Grid B. Pipeline Systems 1. Gas 2. Oil 3. Water C. Mechanical/Batch 1. Trucking 2. Rail D. Radio Frequency Propagation	- Discuss and debate the relative advantages and disadvantages of the use of pipeline systems for fluid transport in comparison to other systems such as trucking, shipping, or rail. Encourage discussion of factors such as economics, environmentalism, etc.
VII. Ethics A. Global Supply/Demand B. Military Applications C. Surveillance D. Environmentalism E. Pollution	- Structure a debate on "Star Wars" technology. Questions probed could be, Is the technology feasible? Should space communications be used for military purposes? Should space communications be employed for surveillance? What about space junk. Will Star Wars lead to the pollution of space? Are the risks worth it?
VIII. Economics A. Supply B. Availability C. Cost D. Scarcity E. R & D F. Development of Emerging Sources	

Student Activities

- Design and build a mosquito repeller using ultrasonic audio power.
- Build a mechanical calculator using Lego, Fisher or Erector components.
- Build a working prototype of a stethoscope.
- Contact the local electrical power company. Ask them to describe the process by which consumption and rates are computed and billed. Document their remote reading capabilities.
- Build a hovercraft. Be certain to consider safety throughout the design and construction process.

Resources & References

- Seymour, R, Ritz, J. & Claghessy, F. Exploring communications. [Section III - Part 1, Books & Resources]
- Pitsco [Section III - Part 6, Sample Suppliers]
- Specialized Products Co. [Section III - Part 6, Sample Suppliers]
- Technovate, Inc. [Section III - Part 6, Sample Suppliers]
- Air Conditioning & Refrigeration Institute [Section III - Part 5, Resource Centers]
- Industrial Heating - The Journal of Thermal Technology. [Section III - Part 2, Periodicals/ Magazines]
- TAM #16: Power Distribution Model. [Section II - Missouri Introduction to E&P Guide]
- U.S. Council for Energy Awareness [Section III - Part 5, Resource Centers, Sample Suppliers]
- Independent Energy [Section III - Part 2, Periodicals/ Magazines]
- O'Leary, B. O. Space industrialization. [Section III - Part 1, Books & Resources]
- Stachwell, J. Future sources. [Section III - Part 1, Books & Resources]
- Naisbitt, J. Megatrends. [Section III - Part 1, Books & Resources]
- Hacker, M. & Barden, R.A. Living with technology. [Section III - Part 1, Books & Resources]
- "Put your physics class in drive." (Feb. 1988). The Science Teacher. [Section III - Part 2, Periodicals/ Magazines]
- Toffler, A. The third wave. [Section III - Part 1, Books & Resources]
- American Council for an Energy Efficient Economy [Section III - Part 7, Associations/ Organizations]

Missouri

Introduction to Energy & Power Technology

Unit 6: Energy & Power Technology Applications

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

Advisory Council Input:

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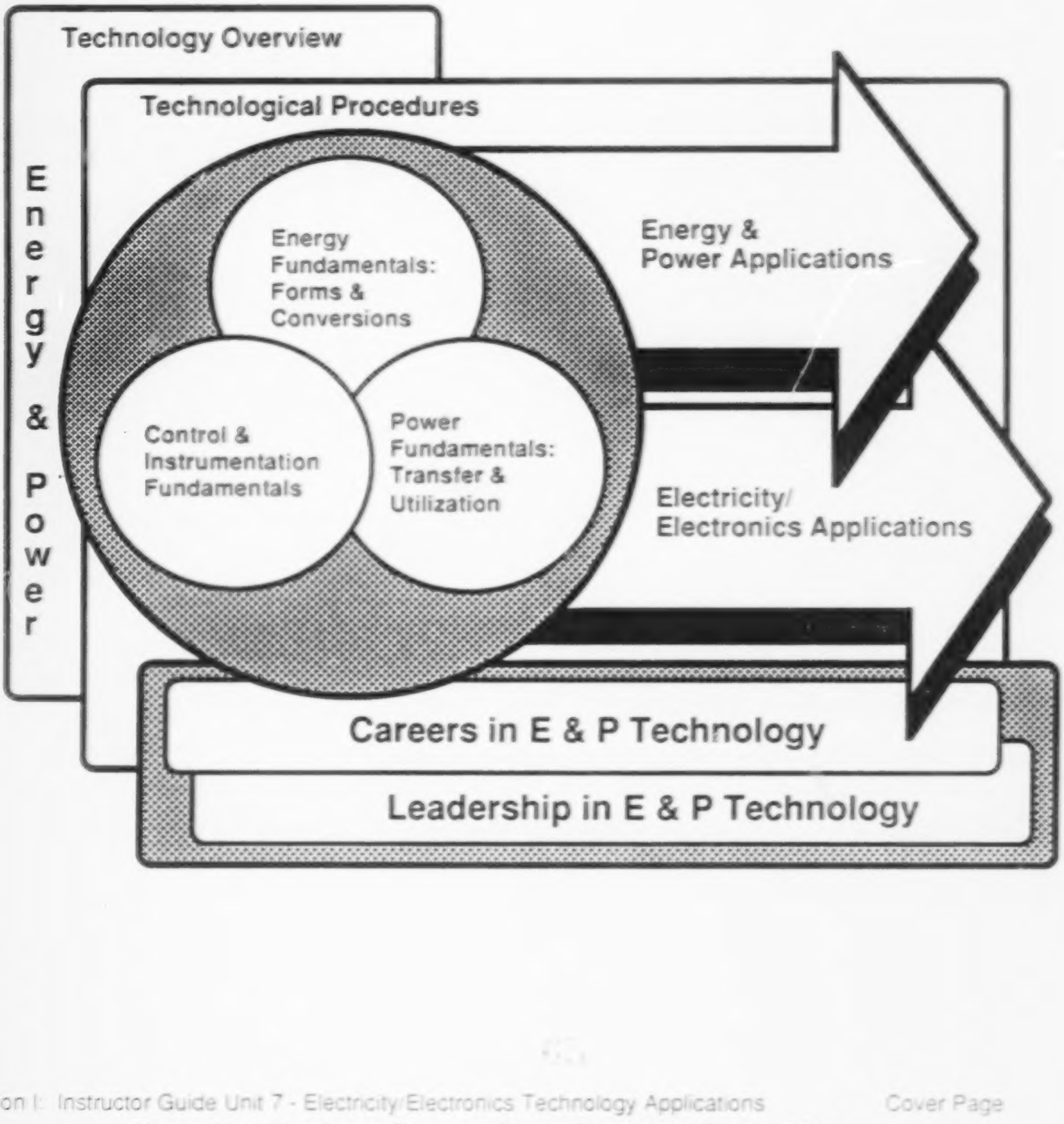
Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 7: Electricity/Electronics Technology Applications


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Seven: Electricity/Electronics Technology Applications

OBJECTIVE: The purpose of this unit is to examine applications of electricity/electronics including safety, measurement, major components, and significant applications.

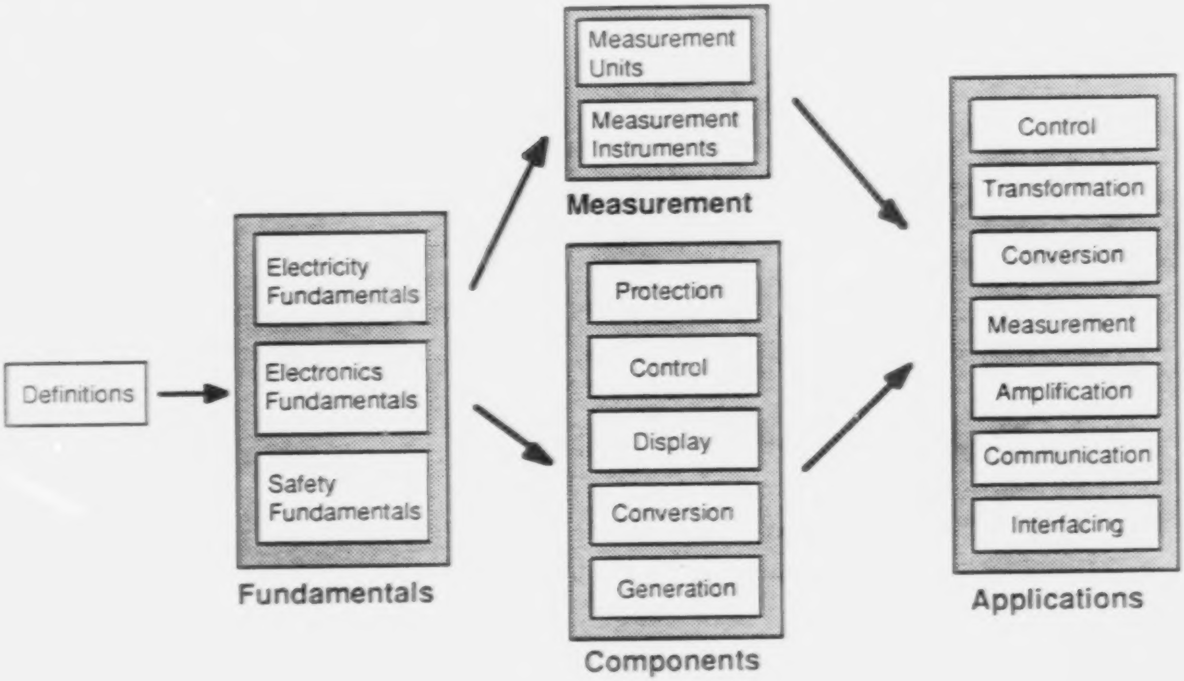
COMPETENCIES -- The student will be able to:

1. Define basic electricity/electronics terms. (7,I)
2. Explain basic electrical laws and use them to solve assigned problems. (7,II)
3. Connect series, parallel and series-parallel circuits. (7,II)
4. Describe the principles of magnetism and electromagnetism. (7,II)
5. Differentiate between alternating and direct current and demonstrate the differences. (7,II)
6. Explain basic electron theory and its application to electricity/electronics. (7,II)
7. Explain and demonstrate the principles of static electricity and dynamic electricity. (7,III)
8. Draw and read basic electrical schematic diagrams. (7,III)
9. Describe the basic concept of solid state circuitry. (7,III)
10. Interpret logic diagrams. (7,III)
11. Differentiate between digital and analog circuits and components. (7,III)
12. Explain the construction and use of integrated circuits. (7,III)
13. Identify and describe the major electrical and electronic components used in conventional applications. (7,IV)
14. Use electronic components to build temporary and/or permanent circuits. (7,IV)
15. Identify and define the sources of electricity. (7,IV)
16. Identify the major types of materials and supplies used in electricity/electronic technology. (7,IV)
17. Identify and describe the essential features of the equipment used in electricity/electronic technology. (7,IV)
18. Assemble basic audio amplifiers and describe their operation and purposes. (7,IV)
19. Define basic storage systems for static and dynamic electricity. (7,IV)
20. Describe the electrical supplies/materials for residential wiring, commercial wiring, and industrial machine wiring. (7,IV)
21. Install electric motors and controls. (7,IV)
22. Operate basic electrical/electronic test instruments and equipment such as ammeters, voltmeters, ohmmeters, multimeters, oscilloscopes and the like. (7,IV)
23. Identify and use electrical and electronic symbols. (7,V)
24. Define basic electrical terminology and units of measure. (7,V)
25. Perform basic mathematical calculations in the quantitative solution of electrical/electronic problems. (7,V)
26. Explain systematic and safe procedure in setting up experimental circuits and servicing equipment. (7,VI)
27. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to electricity/electronic technology. (7,VI)
28. Exhibit positive work habits and attitudes as they relate to the safe and skillful operation of electric/electronic tools and equipment. (7,VI)
29. Describe the problems of high voltage distribution. (7,VI)
30. Identify key features of residential electrical codes. (7,VI)
31. Develop problem solving and creative abilities involving the materials, equipment, processes, and products of electricity/electronics technology. (7,VII)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content	Teacher Plans & Activities
I. Definitions A. Amperes B. Analog C. Binary D. Capacitance E. Circuit F. Coulomb G. Digital	- Develop a worksheet in which students can define and illustrate the key concepts and components involved in electricity and electronics applications. Illustrate each with key demonstrations. Collaborate with the school's science teacher if appropriate.

Lesson/Activity Outline


Definitions
Electricity Fundamentals
Electronics Fundamentals
Safety Fundamentals
Fundamentals
Measurement Units
Measurement Instruments
Measurement
Protection
Control
Display
Conversion
Generation
Components
Control
Transformation
Conversion
Measurement
Amplification
Communication
Interfacing
Applications

Student Activities

- Work with software program modules focusing on electrical components and symbols, introduction to circuits, resistance and color codes, series/parallel circuits, etc. (Available from Advanced Microsystems Technology)
- Build a display unit showing parallel systems that illustrate electrical principles, one with water and one with the comparable electrical components. Use screen printing and/or desktop publishing to develop high quality labels and then display them in an all school display case.

Resources & References

- Advanced Microsystems Technology. Excellent software programs. [Section III - Part 8, Software]
- Malvino Whole Brain electronics software (both Apple and IBM) [Section III - Part 8, Software]

Content	Teacher Plans & Activities
H. Induction I. Magnetism J. Motor K. Ohms L. Phase M. Transformer N. Volts O. Watt	- Develop a presentation which compares electronic terms with water flow. Examples include: diode = check valve, water pressure = emf (electromagnetic field, wire = pipe, storage tank = capacitor, flow of water = current, restriction = resistor, etc.) - Demonstrate Ohm's law using an ammeter. - Demonstrate the use of a Volt-0hm meter. - Have the students design and build a permanent magnet (PM) motor. - Throughout this unit refer to sources such as Popular Electronics, Radio Electronics, and Popular Science. They are packed with manageable and realistic electronics activities that work with students. Make an effort to guide students toward appropriate resources for their own reading.
II. Electricity Fundamentals A. Amperage B. Current flow 1. A.C. 2. D.C. C. Ohm's Law D. Molecular Theory E. Law of Magnetism F. Electrical circuits 1. Open circuits 2. Short circuits 3. Parallel circuits 4. Series circuits G. Electron Theory H. Voltage	- Develop a laboratory experiment that will demonstrate the interrelationship between electricity and magnetism. - Throughout this unit, it is critical that constant and frequent attention be given to electrical safety procedures and considerations. - Demonstrate the difference between electron movement and hole movement using marbles or Ping-pong balls in a tube. - Have a nurse or a physician speak to the class about the serious physical consequences of electrical shock to the human body.
III. Electronics Fundamentals A. Analog 1. Alternating current 2. Direct current	- Have the students plot a sinusodial wave for an AC waveform. - Demonstrate and discuss half and full wave rectification and their applications in model train and race car power supplies and battery chargers..

Student Activities

- Test a variety of materials with an ohmmeter. Try materials such as wood, plastic, aluminum, brass, the human body, etc. Which materials are surprising? How do resistance values relate to the way the materials are used in products? Provide examples.

- Assemble a resistor ladder network used to demonstrate voltage drops. This exercise provides an excellent illustration of Kirchoff's Law.

- Construct a motor and generator from a kit (available from Lab Volt, Radio Shack, etc.)

- Research an historical figure who was a pioneer in energy and power. Interesting examples include Ampere, Kirchoff, Kelvin, Edison, Tesla, etc. Many of these persons had colorful and remarkable careers.

- Work with the drama teacher in your school to develop a skit (or series of skits) portraying the person(s) that have been researched. A series of short skits could be developed as a class and then be presented as a community wide school program.

- Construct a two-pole DC motor from in-shop materials. Pay attention to electrical safety throughout the activity. Write a report explaining what was just built.

- Make a mobile depicting a typical atom, such as copper, argon, etc. complete with a protons, neutrons, and electrons.

- Use software to learn about the basics of electricity/electronics. Design and construct a speed control.

- Construct a Jacob's ladder or tesla coil. (See Popular Electronics or Radio Electronics)

- Construct a telegraph sounder using an electromagnet.

Resources & References

- Union Electric films
  [Section III - Part 4, Media Sources]

- Rural Electric Association (REA)
  [Section III - Part 5, Resource Centers]

- Electrification Council
  [Section III - Part 5, Resource Centers]

- Radio Shack
  [Section III - Part 6, Sample Suppliers]

- Popular Electronics
  [Section III - Part 2, Periodicals/ Magazines]

- Popular Science
  [Section III - Part 2, Periodicals/ Magazines]

- Edison Electric Institute
  [Section III - Part 6, Sample Suppliers]

- Lab Volt Systems
  [Section III - Part 6, Sample Suppliers]

- Odyssey of the Mind
  [Section III - Part 5, Resource Centers]

- Union Electric (booklets on meter reading).
  [Section III - Part 5, Resource Centers.]

- TAM #17: Applying Electric Motors.
  [Section II - Missouri Introduction to E&P Guide]

- TAM #14: Superconductivity: Making it Work for Us.
  [Section II - Missouri Introduction to E&P Guide]

- Projected Learning Programs Inc.
  [Section III - Part 5, Resource Centers]

- Radio Electronics
  [Section III - Part 2, Periodicals/ Magazines]

- TAM #11: Robot Control.
  [Section II - Missouri Introduction to E&P Guide]

Content

B. Digital
   1. Binary counting
   2. Binary logic gates
   3. Counters
   4. Digital display systems
   5. Flip-flops
   6. Integrated circuits
   7. Shift registers

IV. Electricity/Electronics Components

A. Protection
   1. Circuit breakers
   2. Fuses

B. Control
   1. Capacitors
   2. Coils
   3. Diodes
   4. Integrated circuits
   5. Resistors
   6. Transistors

C. Display
   1. LED displays
   2. Liquid crystal
   3. Cathode ray tubes
   4. Laser

D. Electrical Energy Conversion
   1. Alternators
   2. Generators
   3. Motors
   4. Relays
   5. Rotors
   6. Transformers

Teacher Plans & Activities

- Have the students construct the digital tester available from the Instructional Materials Laboratory.

- Engage the students in the design and construction of a digital count down timer for a rocket. (see Getting started in electronics resource "Resources" section.

- Use the game, Towers of Hanoi, to illustrate binary codes. The game involves the movement of concentric rings from one pole to another with the use of three poles. When finished, the rings must be in the same order that they were on the original pole.

- Demonstrate the principle of a fuse using fine wire and a battery. Prepare a setup in which the wire melts under excess current flow.

- Have your students conduct a search for as many types of fuses and circuit breakers as they can. Suggest places to search such as old buildings, hardware stores, antique dealers, etc. As a class discuss the interesting ways that the various fuses relate to their function and time in history. Make an illustrated display of the collection for display purposes.

- Have the students obtain a collection of catalogues containing fuses and other electrical devices.

- Explain the functions of various electronic control components. Develop laboratory experiments to illustrate their uses. (160-N-One kit from Radio Shack)

- Demonstrate arcing with a relay. Then show arcing repression by using a bypass capacitor.

- Demonstrate the effect of holding a magnet up to an operating T.V. screen. Observe and discuss the results.

- Develop an activity that will interface a computer with a robot. Have the students write a simple BASIC program to operate the robot.

- Arrange for a local or regional electric utility company representative to come and speak to the class about power shedding.

- Construct a line protecting device using a latching drop out relay.

Student Activities

- Use a solderless breadboard to construct a variety of circuits developed by your instructor.
- On a scale model wall section, wire typical house wiring configurations, including one, two and three way switches, outlets, rheostats, etc.
- Make a circuit tester.
- Make a night light with a plug, a NE-2 bulb, 22K resistor casting the resin in an ice cube tray.
- Using a breadboard, integrated circuits, resistors, jump wiring, LEDs, and a power source construct a variety of prescribed digital circuits outlined by your instructor. These may include flip-flops, counters, simple gating, encoding, decoding and more.
- Construct a three-way light switch.
- Design and construct a three minute timer for eggs or phone calls.
- Construct a tone generator for telephone dialing.
- Build digital projects such as digital dice, a binary clock, a roulette wheel, electric Ping-pong, etc.
- Build an infinity mirror.
- Build a color organ.
- Use software modules on fundamentals of digital circuits focusing on binary number systems, codes and conversions, logic gates, sequential circuits, flip-flops, etc. (available from Advanced Microsystems Technology)
- Make a digital display sign. This could be in the form of a name tag, tie tac, sign, etc. (see electronics magazines for ideas).
- Build an electronic kit project
- Design and make a printed circuit board.
- Build a working stroboscope. Use the device to test rotating devices such as ceiling fans, PTO shafts, etc. (See TAM #18)
- Build a working tachometer and use to test rotating devices. (See TAM #18)

Resources & References

- EKI kit
  [Section III - Part 5, Resource Centers]
- Radio Shack
  [Section III - Part 6, Sample Suppliers]
- Instructional Materials Laboratory
  [Section III - Part 5, Resource Centers]
- Getting started in electronics. Available from Radio Shack
  [Section III - Part 6, Sample Suppliers]
- Macauley, D. The way things work.
  [Section III - Part 1, Books & Resources]
- Mouser Electronics
  [Section III - Part 6, Sample Suppliers]
- AIT Video. Energy, Principles of Technology series. MVRC
  [Section III - Part 4, Media Sources]
- Kelvin Electronics
  [Section III - Part 6, Sample Suppliers]
- E & L Bug Book Series, Blacksburg, VA
  [Section III - Part 1, Books & Resources]
- Radio Electronics
  [Section III - Part 2, Periodicals/ Magazines]
- Popular Electronics
  [Section III - Part 2, Periodicals/ Magazines]
- Bussman Fuse Corporation
  [Section III - Part 6, Sample Suppliers]
- Advanced Microsystems Technology
  [Section III - Part 6, Sample Suppliers]
- Digi Key Catalog from Digi Key Corp.
  [Section III - Part 6, Sample Suppliers]
- EKI
  [Section III - Part 6, Sample Suppliers]
- Graymark
  [Section III - Part 6, Sample Suppliers]
- Chaney Electronics
  [Section III - Part 6, Sample Suppliers]

Content

- E. Power Generation
  1. Chemical
  2. Light
  3. Heat
  4. Friction
  5. Mechanical
  6. Magnetic

V. Electricity/Electronics Measurement

- A. Units of measure
  1. Amperes
  2. Kilowatt-hour
  3. Ohms
  4. Volts
  5. Watts
- B. Instruments
  1. Ammeter
  2. Ohmmeter
  3. Voltmeter
  4. Wattmeter

VI. Electricity/Electronics Safety

- A. Hazard Types
  1. Conductivity
  2. Electrical burns
  3. Electrical shock
  4. Explosion
  5. Heat
- B. Safety Organizations
  1. National Electrical Manufacturers Association
  2. National Safety Council
  3. Occupational Safety and Health Administration
  4. Underwriters Laboratories

VII. Electricity/Electronics Applications

- A. To control
- B. To transform
- C. To convert
- D. To measure
- E. To amplify
- F. To communicate
- G. To interface

Teacher Plans & Activities

- Demonstrate a Vandergraf generator.
- Demonstrate the use of a two permanent magnet motor as a generator.
- Discuss static and its negative effects on electronic circuitry and components.
- Demonstrate static detection with a neon bulb.
- Have students measure current and compute the maximum load of the two permanent magnet motor generator.
- Discuss how 220 three-phase is more economical than 110 or 220 single-phase.
- Show the films "Think Hot" and "Zap Rap".
- Have the students gather news clippings dealing with electrical accidents. As a class analyze the situations for factors which contributed to the accident. Have students identify factors which could have prevented the accident.
- Have students research the "old times" to see how electrical equipment has matured and developed. One way to do this would be to have them interview someone who has been in electronics related service work for a number of years. Another method is to visit a museum.
- Demonstrate a ground fault device. Discuss appropriate applications and their critical importance in real life situations.
- Demonstrate proper procedures for touching electrical gear, e.g. using the back of the hand rather than the palm of the hand.
- Have the students think through the design and construction of a stethoscope.
- Refer to popular mechanical and electrical magazines such as, Popular Electronics and Radio Electronics for an abundance of interesting project ideas.

Student Activities

- Discuss the history of electricity/electronics components and developments such as the dry cell, the wet cell, important experiments, etc.
- Perform an experiment producing electricity with items such as cheese, lemons, or milk.
- Construct a simple electric motor.
- Construct a telephone from carbon batteries. (carbon earphones).
- Connect a microphone to an oscilloscope and view your voice. Try it with some very different types of voices to see what differences there are.
- Measure the voltage on the output of a stereo. Calculate the wattage for the stereo based on the voltage and speaker ohm reading.
- Visit with a nurse, an industrial safety expert, or a physician about the effects of noise on the human ear.
- Obtain reading from an electrical system using an ammeter, an ohmmeter, a voltmeter, and a wattmeter.
- Construct a graph comparing volts, ohms, and current.
- Construct an electronic variable speed control for a universal motor. Example applications are a drill or a router.

Resources & References

- Bame, A. Exploring technology.
  [Section III - Part 1, Books & Resources]
- Creative Learning Systems Inc.
  [Section III - Part 5, Resource Centers]
- TAM #14: Superconductivity: Making it Work for Us.
  [Section II - Missouri Introduction to E&P Guide]
- Laser & Optronics
  [Section III - Part 2, Periodicals/ Magazines]
- A pamphlet that comes with a "class pack" of dry cell battery kits. Available from Burgess Inc. Freeport, IL 61032
  [Section III - Part 4, Media Sources]
- IASCO (Industrial Arts Supply Co.)
  [Section III - Part 6, Sample Suppliers]
- Electronic System Design Magazine
  [Section III - Part 2, Periodicals/ Magazines]
- Check battery displays in retain stores for pamphlets that are sometimes available at those locations.
- Union Carbide Corporation
  [Section III - Part 5, Resource Centers]
- Edison Electric Institute
  [Section III - Part 5, Resource Centers]
- Popular Electronics
  [Section III - Part 2, Periodicals/ Magazines]
- Radio Electronics
  [Section III - Part 2, Periodicals/ Magazines]
- Jerryco Inc
  [Section III - Part 6, Sample Suppliers]
- Karwatka, D. Discovering technology, energy, power, and transportation
  [Section III - Part 1, Books & Resources]

Missouri

Introduction to Energy & Power Technology

Unit 7: Electricity/Electronics Technology Applications

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

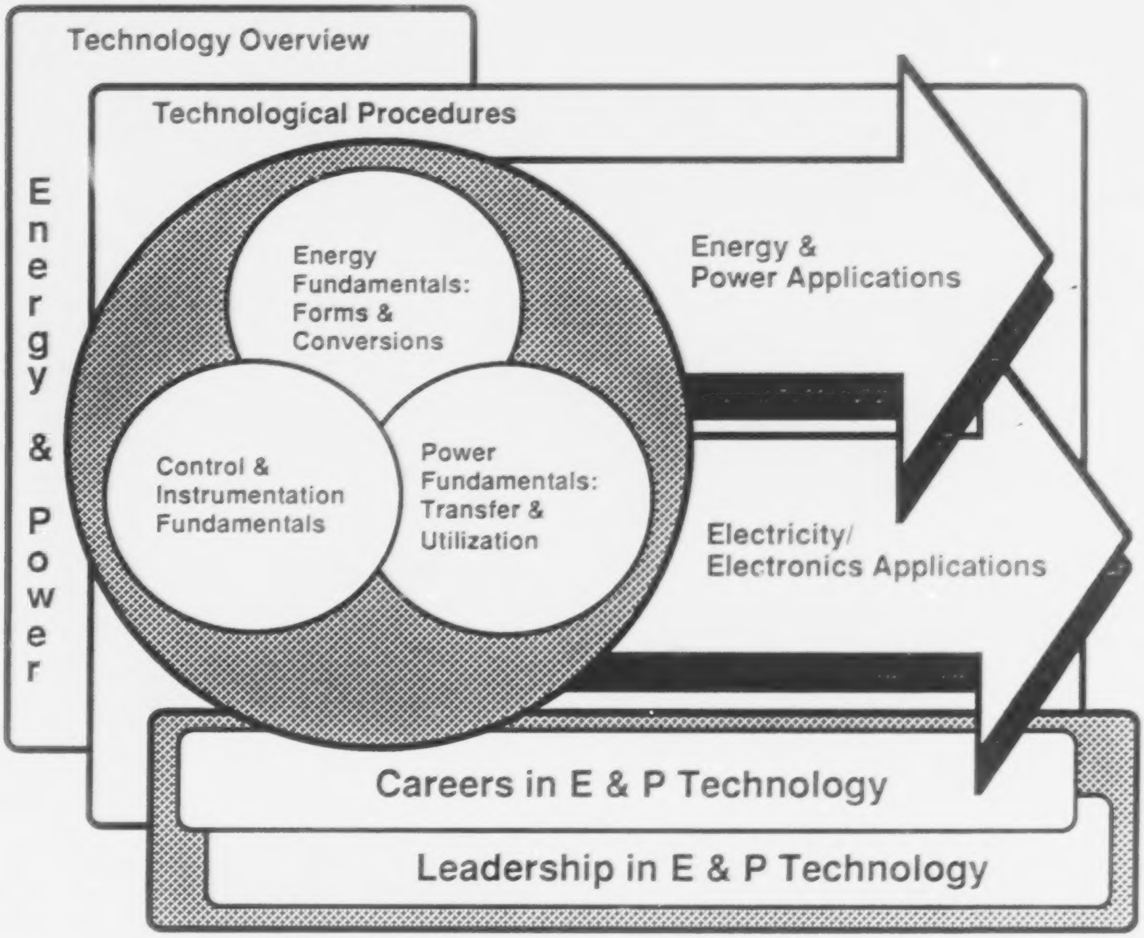
Advisory Council Input:

Missouri

Introduction to Energy & Power Technology

Instructor Guide

Unit 8: Careers in Energy & Power Technology


Technology Overview
Technological Procedures
Energy & Power
Energy Fundamentals: Forms & Conversions
Control & Instrumentation Fundamentals
Power Fundamentals: Transfer & Utilization
Energy & Power Applications
Electricity/ Electronics Applications
Careers in E & P Technology
Leadership in E & P Technology

Unit Eight: Careers in Energy & Power Technology

OBJECTIVE: The purpose of this unit is to assist students in the process of personal and occupational assessment in Energy and Power related areas.

COMPETENCIES -- The student will be able to:

1. Describe the potential for entrepreneurial activity in energy & power technology. (8,I)
2. Identify and classify occupations in the energy & power technology industry. (8,I)
3. Identify and describe career and technological trends in energy & power technology. (8,I)
4. Explore career choices in engineering and related technological areas. (8,I)
5. Differentiate among various career roles, levels and functions in energy & power technology. (8,I)
6. Identify preparatory routes that lead to tentative career choices. (8,I)
7. Assess his/her personal characteristics, talents and interests as they relate to a career in energy & power technology. (8,II)
8. Research and describe occupational prospects of various energy & power technology occupations. (8,III)
9. Demonstrate appropriate employability skills in job identification, seeking and application. (8,III)
10. Demonstrate personal characteristics: interpersonal relations, dependability, work attitude, communication ability, and personal hygiene/grooming, appropriate to employability. (8,III)
11. Demonstrate informed and meaningful occupational and educational choices. (8,III)
12. Express a positive self-concept and attitude regarding equipment, productive effort, and safety for him/her-self and others. (8,III)
13. Demonstrate the ability to access resources that provide information relative to Energy and Power careers. (8,III)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Segments and Trends of Industry
  A. Industry Segments
    1. Manufacturing
    2. Service
    3. Sales
    4. Transportation
    5. Construction
  B. Career Directions and Trends
    1. Engineer
    2. Entrepreneurship
    3. Facility operation
    4. Maintenance
    5. Production worker
    6. Research & development
    7. Scientist
    8. Technician
    9. Vehicle operation

Teacher Plans & Activities

- Arrange for field trips to local E&P related industries, e.g., a utility company, an electrical motor repair shop, a computer diagnosis and repair facility, etc. Have students be alert to safety concerns during the experiences.

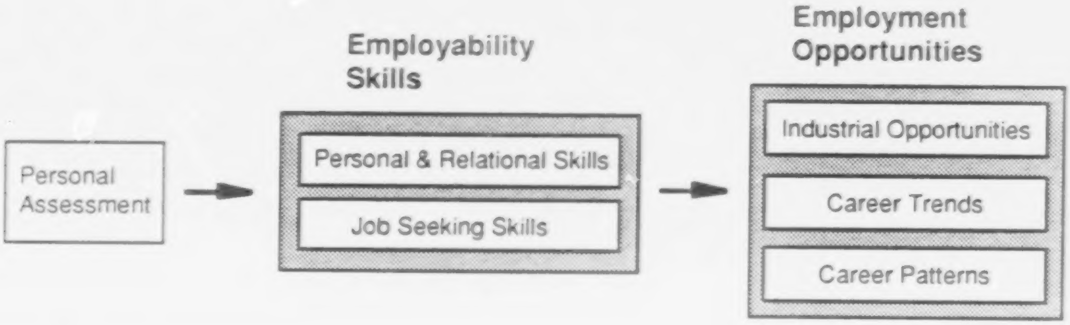
- Invite individuals, perhaps parents of students, who are involved in E&P related phases of industry to speak to the class about their jobs. Encourage discussion of technical material, likes and dislikes about the job, future projections and anticipated changes, etc. Examples include electricians, R&D personnel, a race car mechanic, service personnel, etc.

- Survey the students to see what occupations their parents have. Discuss ways in which those careers may be E&P related. Be creative. Get students to identify connections.

- Use information obtained from the parental survey to identify parents who would make good E&P related speakers/presenters to the class.

- Have students visit with an individual employed in an interesting E&P related career. What kinds of educational experiences or background would that person recommend for a young person preparing for a job in that area?

Lesson/Activity Outline



Student Activities

- Fill out a job application from an employer in your community. Does the form provide the employer with all of the information you think needs to be known about you and your background or abilities? Have the completed application evaluated by your instructor.
- Develop a documentary video on jobs. Include as much E&P related material as you can find. This might include short, person-on-the-street interviews, segments of people working, some commentary, music, etc. An interesting component could be some projections of what future jobs might be like.
- Get an after school job in an area that you think you would like to explore as a future career possibility.
- Arrange to interview a person in your community who works in an occupation that appeals to you. Inquire into their background, their education and preparation for their present position. Ask about the likes and dislikes of the job. Ask for their best advice for you as you look toward your future (in terms of education, experiences, etc.)

Resources & References

- MOView
  [Section III - Part 4, Media Sources]
- SIGI +
  [Section III - Part 4, Media Sources]
- Chamber of Commerce
- Yellow Pages
- Wall Street Journal
  [Section III - Part 2, Periodicals/ Magazines]
- MCE - Emerging Occupations Interest Inventory. Software for Apple/IBM (Includes goals, objectives, teaching strategies, etc. plus detailed information on many occupations) Available from NGG Associates
  [Section III - Part 8, Software]
- ITE Video. 21st Century Skills Series - You Can Do It. MVRC
  [Section III - Part 4, Media Sources]

Content	Teacher Plans & Activities
II. Personal Assessment A. Personal Aptitudes B. Personal Interests C. Personal Skills D. Potential Skills	- Arrange for your students to take a vocational interest inventory, such as Strong's Vocational Interest Inventory. Following this exercise, have the them predict the test results. Discuss the differences and similarities between the two. - Brainstorm with the students a listing of the skills that they think employers want to have in their employees. Refine and cluster the list into categories. As a second component of the activity arrange for a panel of 3-4 employers to discuss the same issue in front of the class. Compile a list of their priorities. Once this is done, reveal the students' list. Discuss the interesting contrasts and similarities.
III. Employability Skills A. Job Seeking Skills 1. Applying for jobs 2. Evaluating jobs 3. Interviewing for jobs 4. Negotiation 5. References 6. Resumes	- Have the students prepare a resume. Focus the information toward getting a job in an E&P related area. Encourage them to develop a professional appearing document by using a desktop publisher and laser printer if available. - Have students identify what, for them, would be the ideal job. Encourage them to disregard practical considerations such as how they perceive their capabilities, potential, or skills. Then, have them identify and write down five factors that give the job appeal. Compile their lists. In a class discussion compare their feedback with other factors that enhance job satisfaction that may have been missing from their perspective. - Modify and/or expand the previous activity to focus on the least appealing job that they can imagine. Identify factors associated with those jobs.
B. Personal & Relational Skills 1. Able to communicate with others 2. Able to get along with co-workers 3. Demonstrates respect for others 4. Dependable 5. Punctual 6. Reliable 7. Self-directed 8. Shows initiative 9. Willing to follow directions -Able to accept & profit from criticism -Cooperative -Persevering -Willing to learn -Personal hygiene	- Set up a video-taped role play, job interview situation. Play back and review. - Arrange for students to interview employers. As a group activity formulate questions that may be asked. Focus the questioning in two areas. First, what kinds job skills does a person need to have to be successful in the company? Second, what kinds of personal skills does that employer value? - Working with other departments in the school (drama, business, and others) develop a series of short skits on getting or keeping a job. Encourage creativity, humor, dramatics. Focus could include hygiene, ear rings, hair length, dealing with criticism, and much more. Arrange to have them presented as a school program.

Student Activities

- Compile a list of E&P related job opportunities from your local newspaper want ads for one week. What kinds of jobs the most plentiful? What kinds and levels of education are typically required?

- Discuss the statement, "Safety is the most important skill that employers look for." Do you agree or disagree? Why?

- Identify a person in your community who has been successful in their occupation. Identify and write down five factors that look to you to have made them successful. Then interview that person and ask them to identify the factors which they say have made them successful. What are the similarities or differences of the two lists?

- Do a role pay of a job interview. Do the interview with one of the teachers in the school or, if possible, an actual employer. Video tape the interview. Review the interview to see how you would do it better the next time.

- Make a list of the five best careers that you can think of in an energy and power related field. What about the careers appeals to you most.

- Have a contest to see who can dream up the most interesting and probable career that will exist in the year 2000 that doesn't exist today in the energy and power area.

Resources & References

- Dictionary of occupational titles (DOT)
  [Section III - Part 1, Books & Resources]

- TAM #19: Getting the Job/Scholarship You Want.
  [Section II - Missouri Introduction to E&P Guide]

- TAM #14: Career Development.
  [Section II - Missouri Introduction to Materials &Processing Guide]

- Cetron, M. Jobs of the future: The 500 best jobs.
  [Section III - Part 1, Books & Resources]

- MOView
  [Section III - Part 4, Media Sources]

- American Society of Heating, Refrigeration and Air Conditioning
  [Section III - Part 7, Associations/ Organizations]

- National LP-Gas Association
  [Section III - Part 7, Associations/ Organizations]

- Environmentalists for Full Employment
  [Section III - Part 7, Associations/ Organizations]

- Ryan, J. Choices & goals: An individualized career exploration computer program.
  [Section III - Part 1, Books & Resources

- Kimbrell, G. Succeeding in the world of work
  [Section III - Part 1, Books & Resources

- Holland, L. J. The occupations finder.
  [Section III - Part 1, Books & Resources

- Farr, J. M. The work book: Getting the job you want.
  [Section III - Part 1, Books & Resources

- Sheffield, C. Space careers.
  [Section III - Part 1, Books & Resources

- AIT Video. Exploring Technology Education. Energy, Power, & Transportation: Section E, MVRC
  [Section III - Part 4, Media Sources]

Missouri

Introduction to Energy & Power Technology

Unit 8: Careers in Energy & Power Technology

Instructor Notes:

Start: _____ End: _____ Items to Order

Suggested Revisions:

Advisory Council Input:

Missouri

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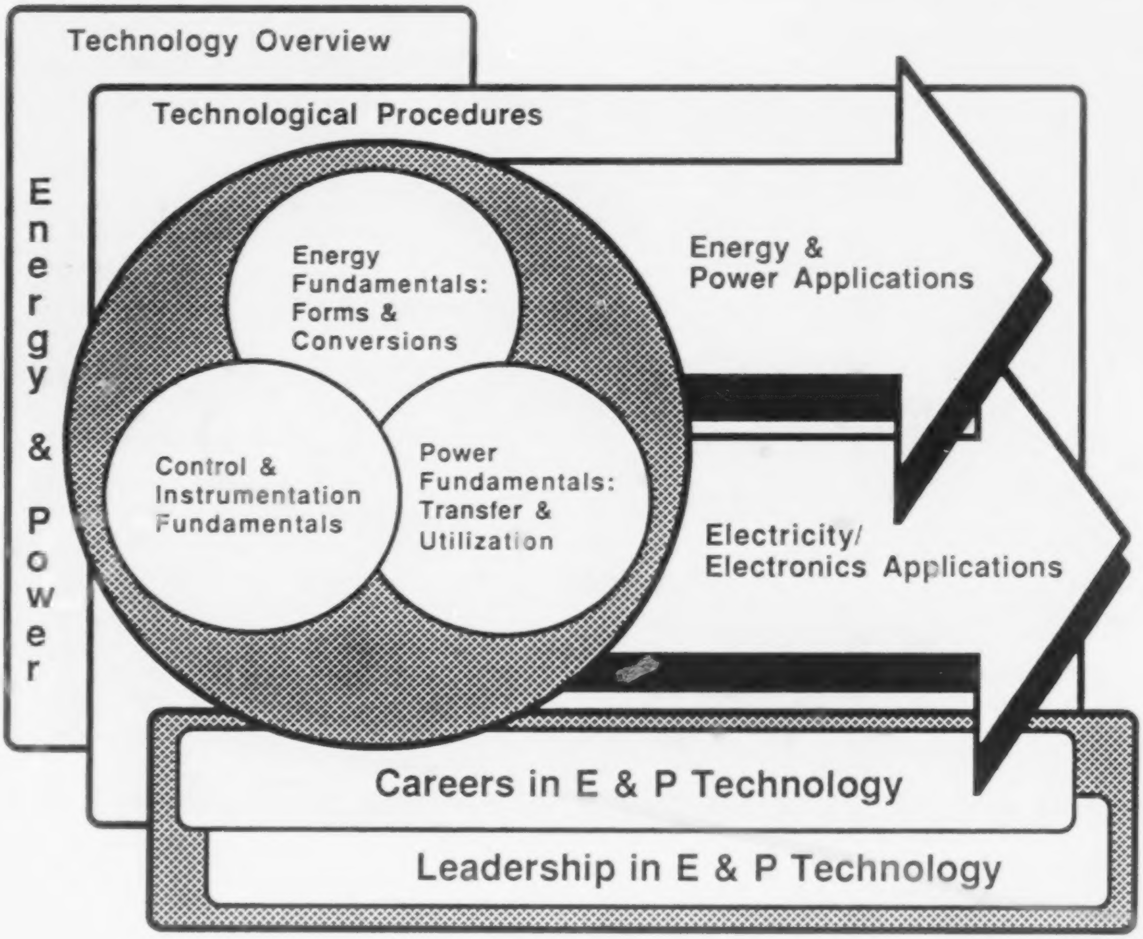
Unit 9: Leadership Roles in Technology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Unit Nine: Leadership Roles in Technology

OBJECTIVE: The purpose of this unit is to focus leadership roles and possibilities for students in areas related to Energy and Power technology.

COMPETENCIES -- The student will be able to:

1. Demonstrate leadership in an individual activity related to the course. (9,I)
2. Work cooperatively with others in leadership and followership roles. (9,II)
3. Bring group activity to a successful conclusion. (9,II)
4. Employ leadership skills in performing officer duties and guiding student organizational activities. (9,III)
5. Describe the purposes of student organizational activities. (9,III)
6. Participate effectively in local, state, and national clubs. (9,III)

*[notations in parenthesis identify the Unit number and Content outline section(s) that the competency refers to]

Content

I. Individual Leadership
   - A. Consistency & Dependability
   - B. Energy
   - C. Initiative
   - D. Know Personal Strengths & Limitations
   - E. Sense of Purpose
   - F. Validate How Others See You
   - G. Styles
     - 1. Hierarchical
     - 2. Networking

II. Group Leadership
   - A. Conflict Resolution
   - B. Effective Communication
   - C. Evolve Vision of Goal(s)
   - D. Inspire Confidence
   - E. Knowledge of Group Dynamics
   - F. Manage Operation
   - G. Organize Resources Effectively

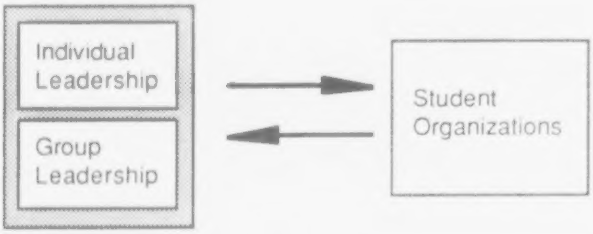
Teacher Plans & Activities

- Conduct a session identifying examples of key historical or contemporary leadership figures, such as Thomas Edison, Henry Ford, George Washington Carver, or Thomas Jefferson. Brainstorm and list what students identify as leadership qualities. Do students agree that they were leaders? What personal and professional qualities can students identify in these persons? How does leadership vary for various personality types (forceful, colorful, shy, thoughtful)?

- Arrange for the administration of a personality type indicator instrument for your students. An example is the Myers-Briggs Personality Type Indicator. Focus the discussion of the results on both self understanding and group relations skills and issues.

- Invite a guest speaker who has a job in management. This might be a production manager, personnel director, a foreman, office manager, lead worker, or others with similar responsibilities. Have them discuss ways in which they approach issues such as conflict between employees, employee evaluation, organizational goal setting, etc.

Lesson/Activity Outline



Student Activities

- Organize a pinewood derby for elementary school students.
- Run for a position in the school government. Promote yourself as a representative of Industrial Technology. Include your peers in the development of a platform which promotes not only yourself but also what your interest and abilities in technology have to offer to the school. Examples include familiarity with design, desktop publishing, photography, etc.
- Set up a recycling service for senior citizens.
- Conduct an energy audit for the school facility. As a club service project, repair caulk, repair cracks, or other items that would improve energy efficiency.
- Examine different ways to run a business such as employee self management, top-down management, quality control circles, etc. Which are the best? What are the positive and negative aspects of each? Do employees have leadership ability? Should employees be leaders?
- Work with TAM #20 on Leadership

Resources & References

- Ericson, Katharine. The solar jobs book. [Section III - Part 1, Books & Resources]
- TAM #15: Leadership Development. [Section II - Missouri Introduction to Materials & Processing Guide]
- Hart, Dwight. Missouri industrial technology student activity Guide [Section III - Part 1, Books & Resources]
- TAM #4 - E&P Guide. Includes a component on the development and organization of a recycling activity. [Section III - Part 1, Books & Resources]
- MERP (Missouri Energy Resource Project, an organization that recycles paper, plastics, cans, etc.) [Section III - Part 5, Resource Centers]
- TAM #20: Operating a Management System. [Section II - Missouri Introduction to E&P Guide]

Content

III. Student Organization Activities
  A. By-laws

  B. Key National Organizations
    1. Epsilon Pi Tau
    2. Junior Achievement
    3. Technology Student Association
    4. Trade/Professional associations
    5. Vocational Industrial Clubs of America

  C. State & Local Organizations
    1. Missouri Industrial Technology Students Association

Teacher Plans & Activities

- Develop a simulation of a big city utility company. Involve students in establishing the parameters, such as profit margin, maintenance priorities, annual budget, employee salaries, utility rates, etc. Divide the class into two groups: consumers and utility management. Create several decision-making scenarios for the two groupings to negotiate. Sample decisions might be who gets cut off first in severe weather conditions and who should pay bills when people are unable to pay.

- Use TAM #20 which focuses on the development of student leadership.

Student Activities

- Join a state or national student organization such as TSA, Missouri Technology Student Association, or others.
- Run for state or national office in a student organization.
- Ask your instructor for information regarding national student conferences including the possibility of your being sent as a representative of your local club, if there would be financial support, etc.
- As a club fund raiser/service activity conduct energy audits of homes and make suggestions for improvements.

Resources & References

- Technology Student Association (TSA)
- Missouri Technology Student Association (Missouri TSA)
- VICA
  [Section III - Part 7, Associations/Organizations]
- Missouri Industrial Technology Education Guide
  [Section III - Part 1, Books & Resources]

Missouri

Introduction to Energy & Power Technology

Unit 9: Leadership Roles in Technology

Instructor Notes:	
Start: _____ End: _______	Items to Order

Suggested Revisions:

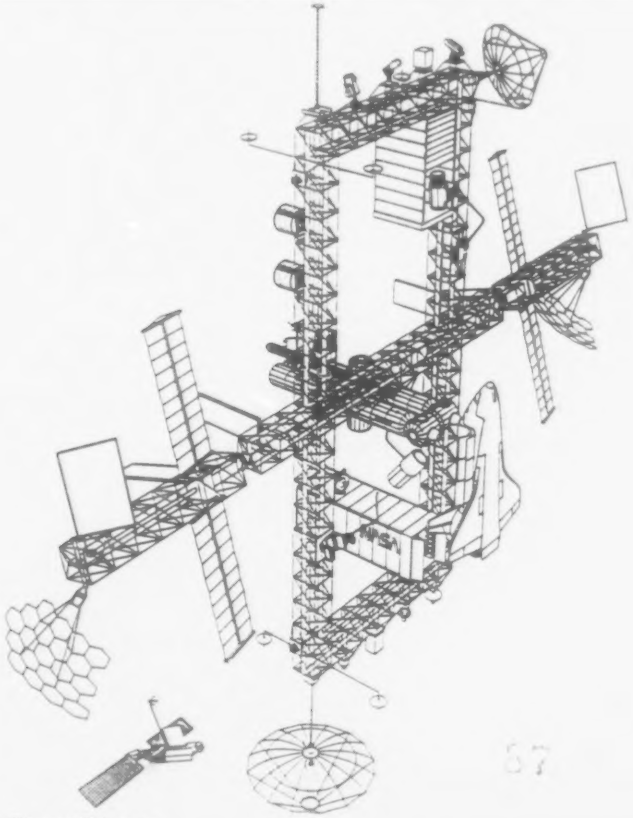
Advisory Council Input:

Course:	Introduction to Energy & Power Technology

Technology Activity Module #1

Energy & Power Odyssey
Applications for the Future

by: Steve Murray



TAM #1: Energy & Power Odyssey
Applications for the Future

Instructor Component

Activity Objectives: **The purpose of this activity is to reinforce how concepts of technology systems and energy & power interface with communication and materials & processing technology. These concepts will be related to economic, environmental, political, psychological, and sociological issues.**

Activity Competencies: By completing this TAM, the student will be able to:

1. Describe and illustrate examples of major types of energy conversion systems, their components and key variables.
2. Describe and illustrate examples of power systems, their components and key variables.
3. Describe how energy & power technology affects communication technology.
4. Describe the relationship between energy & power technology and materials & processing technology.
5. Provide examples of the positive and negative impacts of energy & power technology on society in economic, environmental, psychological, and sociological terms.
6. Demonstrate the safe and proper use of energy & power tools, equipment, and materials.
7. Use the physical principles of simple machines to explain the operation of power transmission systems.

Module Instructions

Introduction:

This activity is designed to allow the students to apply their present knowledge about energy and power technology to the development of a model space station. They will also participate in a field trip and participate in an energy simulation game.

Safety Considerations:

The students are to observe standard safety procedures for operating equipment as established by the instructor. Safety glasses are required at all times while in the laboratory.

Needed Materials:

1. Supplies

A. 2 liter bottles
B. Dowel rods
C. Straws
D. Cans
E. Balsa/cardboard stock
F. Hot glue sticks
H. Spray paint

2. Equipment/Machines/Tools

A. Hot glue gun
B. Band/scroll saw
C. Scissors
D. Standard lab equipment
E. World Energy Simulator
(Available through: The University of Missouri Office of Extension
2820 S. Highway 291
Independence, MO 64057
(816) 373 - 5500

3. Handouts

A. Student component of TAM #1
B. Space Station reading (taken from Popular Science or NASA brochure)

4. Instructional Resources

A. Video/Slides

1. Space station: The next logical step. (0090-02) $15 (video)
2. Human space flight: Large space structures. (100.0-05) $12.50 (45 slides)
Both of the above are available from:

NASA CORE; Lorain County JVS; 15181 Route 58 South; Oberlin, OH 44074

B. Books and Articles

1. Barden, Robert A. & Hacker, Michael. (1988) Living with technology (p. 82-87). Albany, NY: Delmar Publishers.
2. ______________. (1986). Information summaries: Space station. Huntsville, AL: NASA Marshall Space Flight Center.
3. Beauford, Kathy E. & Hagan, Lynn. A teacher's companion to the space station: A multi-disciplinary resource. New Orleans, LA: Michoud Aerospace (PR Department).
4. Schefter, Jim. (March 1989). On base in space. Popular Science, p. 94-99, 141.
5. ______. (1985). Space station: The next logical step. Washington, DC: Superintendent of Documents, Government Printing Office. EP - 213 Stock No. 033-000-00945

6. ______. (1982). The next step: Large space structures. Washington, DC: Superintendents of Documents, Government Printing Office. NF - 129 Stock No. 033-000-00853

C. Software

1. Project: Space Station is available for Apple, Commodore 64, and IBM computers from:

Odyssey
Attn: Merchandise Department
21027 Crossroads Circle
P.O. Box 1612
Waukesha, WI 53187-1612

D. Energy Simulator Resources

1. Energy: A teacher resources guide. Available from Union Electric, which provides information about obtaining energy simulator resources and other useful information.
2. Energy simulator operations manual. Bozeman, MT: University of Montana. Available through The University of Missouri Extension. (see the address and telephone information in the the Equipment section above.)

Management/Logistics:

1. Related TAMS

This TAM is designed to lay a foundation for other activities in the course. However, the TAM can be used independently of others.

2. Evaluation/Grading

A. Evaluate the design/sketch based on the form, function, and creativity.
B. The crafted quality of the final product.
C. Evaluate the pre- and post-tests taken by students.

3. Suggested Schedule/Time

The time suggested for this TAM is one to two weeks.

Key Instructional Suggestions:

1. Safety

No special safety considerations are necessary for this TAM. However, general safety concerns and attitudes should always be stressed as appropriate.

2. Motivation

A. Use the computer software, Project: Space Station
B. Watch video, Space Station: The Next Logical Step
C. Watch slides, Human Space Flight: Large Space Structures

3. Prerequisite Information

The TAM can be completed with no prerequisite information. However, the student will gain more from the unit if suggested resources are read during the initial stages of the TAM.

4. Demonstrations

Demonstrations will need to be given on:

A. Operating the computer software, Project: Space Station.
B. Using the energy simulator (Activity #3)
(**Note**: The simulator can be obtained by contacting:

The University of Missouri Office of Extension
2820 S. Highway 291
Independence, MO 64057
(816) 373 - 5500

5. Reinforcement

This TAM provides an opportunity to reinforce some principles from the biological sciences. Also, the development of various concepts for space station designs provides reinforcement for basic design principles learned in art course work.

6. Attitudes

A. General safety rules should be observed when operating equipment.
B. Housekeeping and general cleanliness are very important.
C. Encourage students to be very creative and resourceful with items chosen for space station model.

7. Remediation/Enrichment

Remediation: Have the students view the video, "Space Station: The Next Logical Step".
Enrichment: Research possible activities/experiments to be done after the space station is actually in service.

8. Summary & Review

In this TAM, students have designed and constructed a model of the space station, Freedom. We have also learned the inter relationships between energy & power, communication, and materials & processing technologies. During the construction of the space station, students developed knowledge about the social impacts of energy & power technology as they relate to the space station. The following are to be reviewed:

A. Social Impacts of energy and power technology
B. Relationship between energy & power and communication
C. Relationship between energy & power and materials & processing
D. Use of simple machines in the development of the space station (model and video).
E. Important parts of the space station.
F. Terms associated with the space station.

9. Review Questions & Answers

A. ___________ is the movement and manipulation of materials, components, supplies, and personnel to and from the space station. (*Logistics*)

B. What is used as the primary energy source for the space station? (*Sun*)

C. The space station will be placed into orbit through a series of ___________ ___________ flights. (*Space shuttle*)

D. The space station will have a module used for ___________ materials that can't be done in gravity. (*Combining*)

E. The space station will have ___________ systems to transfer information to receiving stations on earth. (*Communication*)

Date: ______ Class: ________ Name: ___________________________

TAM #1: Energy & Power Odyssey - Pre-test

Instructions: Answer the following questions in the space provided.

1. What is a space station?

2. List the three clusters of industrial technology.

3. Explain the primary purpose of the space shuttle system.

4. List three important events in the history of our nation's space program.

Date: ________ Class: ________ Name: ______________________________

TAM #1: Energy & Power Odyssey - Post-test

Instructions: Circle the letter for the word that correctly completes the sentence.

1. ____________________ became the first American astronaut in 1961.
   - A. John Glenn
   - B. Alan Shepard
   - C. Gus Grissom
   - D Steve Hawley

2. On July 20, 1969, ______________________ became the first human to step onto another celestial body.
   - A. Neil Armstrong
   - B. Edward White
   - C. John Glenn
   - D. Alan Shepard

3. The space station in development by NASA is called ________________.
   - A. Spacelab
   - B. Mir
   - C. Freedom
   - D. Ecolab IV

4. ________________ are space station components that contain resources and equipment to sustain human life and conduct experiments.
   - A. Logistics
   - B. Modules
   - C. Nodes
   - D. Environments

Instructions: Place the word in the blank that relates to resources and equipment to sustain human life and conduct experiments.

5. ______________________ is moving about outside of a spaceship, space station, or planet.

6. Logistics are the movement and manipulation of materials, components, supplies, and personnel to and from the ____________________________.

7. ______________________________ collect the energy of the sun.

8. The abbreviation, RCS, stands for ________________________________.

9. _____________________________________ consists of the space shuttle and its array of components and payloads.

TAM #1: Energy & Power Odyssey - Test Keys

TAM #1- Pre-test Answers

1. An orbiting laboratory that allows experimentation in a weightless environment.

2. Energy & Power, Materials & Processing, and Communication

3. To transport instruments and people to and from space allowing experimentation.

4. Any of the below.

   - 1962, astronaut John Glenn became the first American to orbit the earth.
   - 1965, Edward White became the first American to walk in space.
   - 1968, Apollo 8 manned mission orbited around the moon.
   - July 20, 1969, "One small step for man, One giant leap for mankind." Apollo 11 manned mission landed on the lunar surface. Astronaut Neil Armstrong became the first human to step on another celestial body.
   - 1973, Skylab space station operation began.
   - 1976, Viking 2 landed on Mars.
   - 1981, first Space Shuttle flight.

TAM #1 - Post-test Answers

1. B
2. A
3. C
4. B
5. EVA
6. Space station
7. Solar cell
8. Reaction Control System
9. Space transportation system

TAM #1: Energy & Power Odyssey
Applications for the Future

Student Component

Introduction:

Since the space shuttle disaster in 1986, NASA has been searching for the next logical step for the space program. A special committee has selected a space station as the next step. The space station needs the capability to allow 16 astronauts on board. Because of this, the space station will need communication systems, energy & power systems, and materials & processing systems to sustain human life for extended periods of time. NASA is sub-contracting the different systems to various contractors. Each contractor is to present a written report on space station features and a model of the space station.

Competencies: Following the completion of this TAM, you will be able to:

1. Describe and illustrate examples of major types of energy conversion systems, their components and key variables.
2. Describe and illustrate examples of power systems, their components and key variables.
3. Describe how energy & power technology affects communication technology.
4. Describe the relationship between energy & power technology and materials & processing technology.
5. Provide examples of the positive and negative impacts of energy & power technology on society in economic, environmental, psychological, and sociological terms.
6. Demonstrate the safe and proper use of energy & power tools, equipment, and materials.
7. Use the physical principles of simple machines to explain the operation of power transmission systems.

Module Overview:

The history of the American space programs is rich with tremendous feats and accomplishments. The first American triumph was in 1961, when Alan B. Shepard became the first American astronaut. Others followed quickly (listed below):

- 1968, astronaut John Glenn became the first American to orbit the earth.
- 1965, Edward White became the first American to walk in space.
- 1968, Apollo 8 manned mission orbited around the moon.
- July 20, 1969, "One small step for man. One giant leap for mankind". Apollo 11 manned mission landed on the lunar surface. Astronaut Neil Armstrong became the first human to step on another celestial body.
- 1973, Skylab space station operation began.

- 1976, Viking 2 landed on Mars.
- 1981, first Space Shuttle flight.

Obviously, these feats directly and indirectly affected society. The space station will soon enter the history books as one of the greatest feats ever in the history of space travel. Perhaps its creator will be . . . . YOU!

The development of the space station requires the coordination of the three clusters of industrial technology. Each cluster has components that are an important part of the space station development and operation. For example, the space station will use advanced construction methods for its development. After the space station is completed, it will use communication systems to transmit information to earth.

The space station will affect society greatly. It will lead to spinoffs of technology that will come about because of the experiments conducted and the knowledge learned through the development of the space station. For example, during the early years of space travel, there was a need for miniaturization of computer circuitry; this miniaturization led to today's home computer.

The space station is an excellent example of the systems model. This unit will discuss the systems model's parts which include input, process, output, and feedback. In relation to the space station, the input is the equipment, supplies, and the space station itself. The process is the activities that will take place on the space station. The output is the result of those activities performed on board the space station. The feedback is the positive or negative impacts of those activities. The space station will also consist of several sub-systems such as energy conversion, power, and instrumentation & control systems.

Key Information:

1. **Class Presentations**
    - Inter relationships between the space station and the three clusters of industrial technology.
    - Impacts of the space station on society.
    - Components of the space station.
2. **Demonstrations**
    - Software operation, Project: Space Station
    - Space station model
3. **Safety**
    - Wear safety glasses at all times
    - Observe all general safety rules stated by your instructor
4. **Personal Activity**

    As your homework, you should read about the space station and its development. Articles can be found in the school's library, in magazines, newspapers, and books. Before starting this activity, you should read the following:

    A. Schefter, Jim. (1989 March). On base in space. Popular Science, 141, p. 94-99.

    B. Brown, Stuart. (1989 July). 20 years after Apollo: Is the US lost in space. Popular Science, p. 63-75.

Glossary:

1. **Extra Vehicular Activity (EVA)** -- Moving about outside of a spaceship, space station, or planet; a spacewalk.
2. **Logistics** -- The movement and manipulation of materials, components, supplies, and personnel to and from the space station.
3. **Modules** -- Space station components that contain resources and equipment to sustain human life and conduct experiments; one module will be for human habitation.
4. **Nodes** -- Units that connect the various modules and components of the space station.
5. **Photovoltaic** -- Solar cells which collect the energy of the sun and use it to drive electricity-producing machines such as turbines.
6. **Reaction Control System (RCS)** -- An arrangement of thrusters that move an object in space. The space station will have several reaction control systems so that its orbit can be adjusted.
7. **Space Transportation System (STS)** -- The space shuttle and its array of components and payloads.
8. **Truss** -- The lattice-work assembly that forms the structural backbone of the space station architecture.

Needed Materials:

1. **Supplies Required**
    - A. 2 liter bottles
    - B. Dowel rods
    - C. Straws
    - D. Cans
    - E. Balsa/cardboard stock
    - F. Scrap materials
    - G. Hot glue sticks
    - H. Spray paint

2. **Equipment**
    - A. Hot glue gun
    - B. Band/scroll saw
    - C. Scissors
    - D. Standard lab equipment

3. **Handouts**
    - A. Pre-assessment
    - B. Space Station picture with identified components

TAM #1: Energy & Power Odyssey
Application for the Future

Activity #1: Space Station - Plan of Procedure

1. Develop sketches of different styles of space stations (Figure #1).

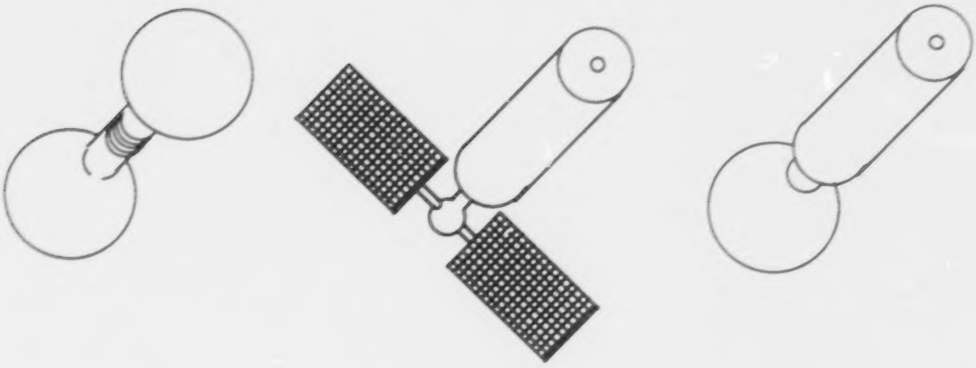


Figure #1 - Sample Space Station Sketches

2. List and gather materials to be used for the development of the space station model (Figure #2).

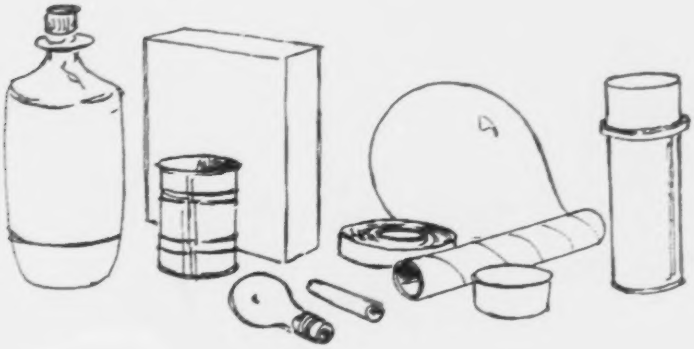


Figure #2 - Materials for Space Station Model

3. Develop a sketch of the space station model and identify the materials and where they are used (Figure #3).

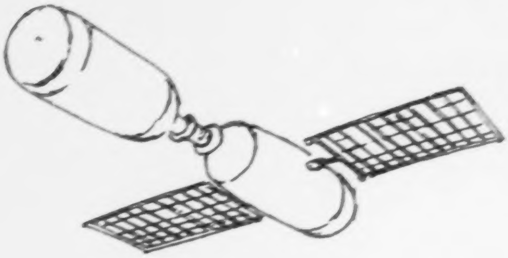


Figure #3 - Sample Model/Material Sketch

4. Construct the space station model after sketch and material approval by your instructor.

5. Finish the model with decals, paint, finish, electrical wiring, etc.

6. Write a report that explains the components of your space station and the purpose of the components. The report is to provide information on social impacts, inter-relationships, and systems on board.

TAM #1: Energy & Power Odyssey
Application for the Future

Activity #2: Field Trip to Local Power Plant - Plan of Procedure

1. Participate in a field trip to a local power plant. This could be arranged by your Industrial Technology Education club (or possibly set up by your instructor). In most communities this will be an electrical power company. Some communities will have facilities that use coal or nuclear sources.

2. During the tour, look for some different things.

   A. Identify the different systems and sub-systems that are involved in the power generation.

   B. Attempt to identify the potential impacts of the particular form of power generation. Remember, impacts can be personal, environmental, global, etc.

   C. At a more specific level, what processes are happening in the plant? What processes are occurring that change the energy source (such as coal) into a power output? How does the plant work?

3. When you return to the school, be prepared to discuss the following:

   A. Is this a safe form of energy? What do you mean by safe? Is it safe to workers? the community?, etc?

   B. Is the energy source efficient? How do you know?

   C. Is the energy source renewable or non-renewable? Why is this consideration important or unimportant?

   D. Do you think the kind of plant that you saw on the tour will be around in 50 years? 25 years? 10 years? Why or why not? If it is no longer being used, what do you think will replace it?

TAM #1: Energy & Power Odyssey
Application for the Future

Activity #3: Energy Simulation Game - Plan of Procedure

The energy simulation game was developed at the University of Montana with funding from the U. S. Department. of Energy. The simulator is designed to accept input from as many as six different players designed to represent different users (representing countries, cities, companies, etc.). Players are able to adjust a variety of energy use variables. For example, a country could choose to increase its dependance on nuclear energy and decrease its use of coal. These decisions will have a corresponding impact on a number of factors, including the total available energy pool, the environmental impact, the number of years to depletion, and more. The game will help you see how many factors are affected even by small changes in energy input and output. The simulator is available from The University of Missouri Office of Extension; 2820 S. Highway 291; Independence, MO 64057; (816) 373 - 5500.

The simulator is pictured below (Figure #4).

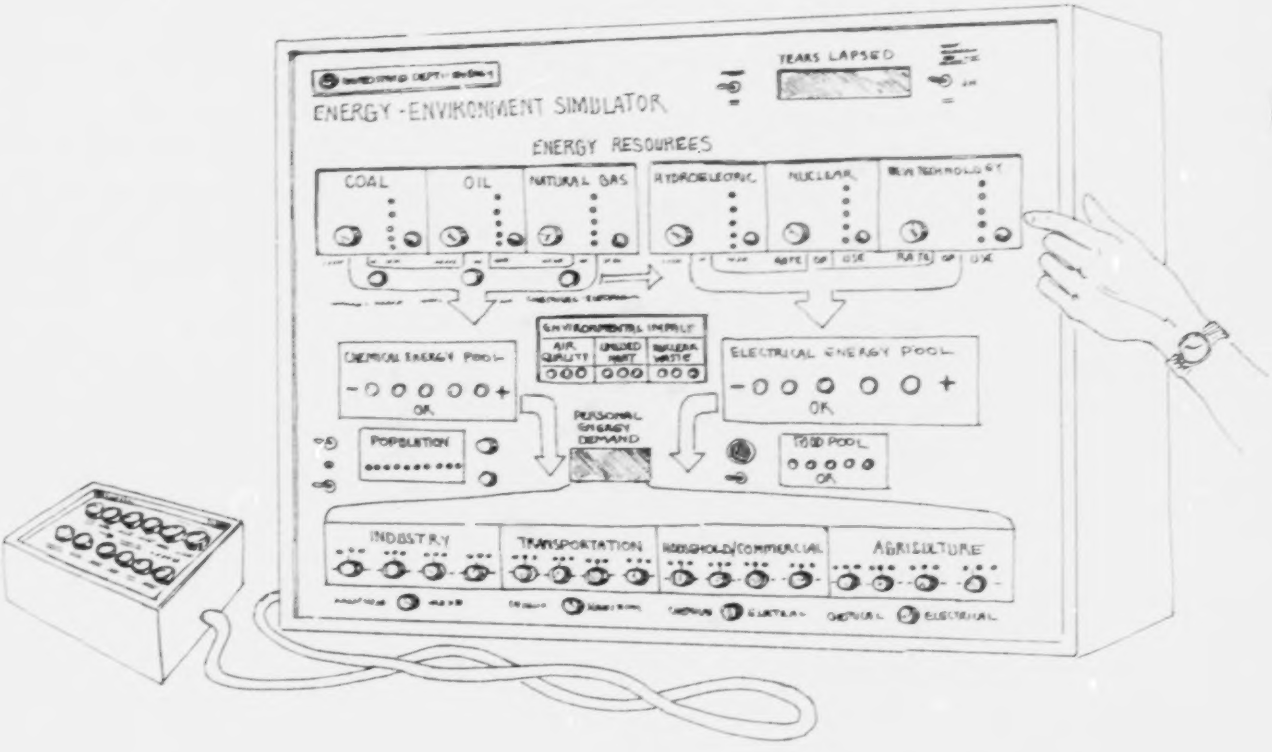

TEARS LAPSED
ENERGY - ENVIRONMENT SIMULATOR
ENERGY RESOURCES
COAL
OIL
NATURAL GAS
HYDROELECTRIC
NUCLEAR
NEW TECHNOLOGY
RATE OF USE
RATE OF USE
ENVIRONMENTAL IMPACT
AIR QUALITY
UNUSED HEAT
NUCLEAR WASTE
CHEMICAL ENERGY POOL
- + OK
ELECTRICAL ENERGY POOL
- + OK
PERSONAL ENERGY DEMAND
POPULATION
FOOD POOL
OK
INDUSTRY
TRANSPORTATION
HOUSEHOLD/COMMERCIAL
AGRICULTURE
CHEMICAL
ELECTRICAL

Figure #4 - Energy Simulator

TAM #1 - Summary

1. **Review & Summary Activities**

   The relationships between the three clusters of industrial technology are very important concepts to understand. NASA's space station, Freedom, is an excellent example of how energy & power, materials & processing, and communication are inter related. Once the space station, Freedom, is in operation, it will allow our scientists to study the environment, produce new materials, develop more efficient power systems, etc. Needless to say, the space station will have a tremendous impact on society and the future of industry. The space station is currently in the pre-stages of development. Perhaps you will one day participate in its design or operation. Who knows? One day you just might live in it.

TAM #1 - Post-assessment

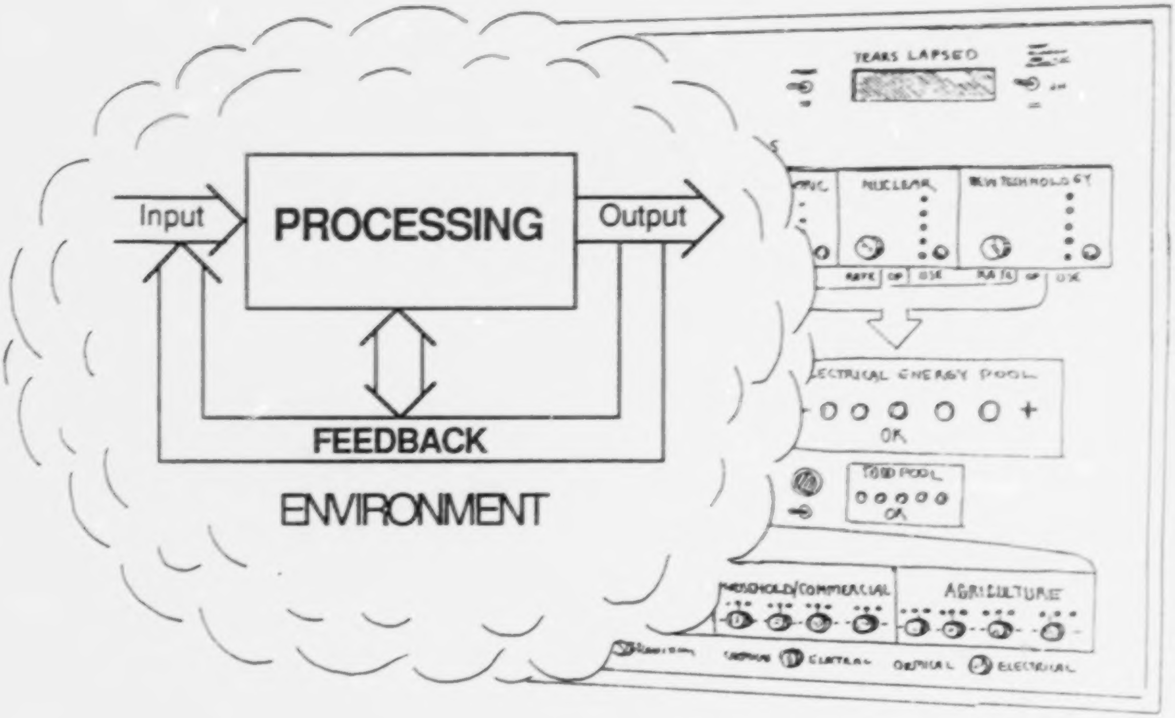
Complete the post-test given by your instructor.

Course: Introduction to Energy & Power Technology

Technology Activity Module #2

Adventures With Systems Theory

by: Michael J. Dyrenfurth


Input
PROCESSING
Output
FEEDBACK
ENVIRONMENT
YEARS LAPSED
NUCLEAR
NEW TECHNOLOGY
RATE
OP
USE
ELECTRICAL ENERGY POOL
OK
FOOD POOL
OK
HOUSEHOLD/COMMERCIAL
AGRICULTURE
THERMAL
ELECTRICAL
ELECTRICAL

TAM #2: Adventures With Systems Theory

Instructor Component

Activity Objectives: There are two ways of using systems theory. One is to use systems analysis to identify the components and subsystems of a larger entity. The other way is to take individual components and subsystems and combine them to build a larger system. The first approach is called systems analysis. The second approach is termed systems synthesis or systems engineering. This TAM contains activities doing each of these major steps. Systems analysis will involve a black box activity and systems synthesis/systems engineering will involve an individual brainstorming and integration activity.

Activity Competencies: By completing this TAM, the student will be able to:

1. Define systems terminology according to the glossary presented in this TAM.
2. Take an unfamiliar system and identify the subsystems and the component parts within it.
3. Identify environmental and feedback mechanisms of existing systems.
4. Describe failings of current systems found in the industrial and environmental world in terms of systems theory.
5. Design a new system using existing components.
6. Sketch a block diagram to represent an actual system and its components.

Module Instructions

Introduction:

Both systems analysis and systems synthesis/engineering depend on a mastery and understanding of systems theory. Systems theory is not an esoteric set of concepts. It's rather simple, but there are some rules, guidelines and concepts that must be clearly understood. Anything less than that will lead you into trouble down the road. All the essential concepts have been defined in the glossary. This activity is completely flexible in that the ITE instructor can use systems theory with any technological cluster or any laboratory environment he or she feels appropriate. Furthermore, this activity can occur at relatively simple levels for the lower grades and at considerably more sophisticated ways at the higher grades or with accelerated students.

The context, then, is simple. Both systems analysis and systems engineering are based on systems theory. When systems theory is used to dissect or identify the components of an existing system, it's called systems analysis. When systems theory and concepts are used to combine components into subsystems and/or overall systems, it's called systems design or engineering.

Safety Considerations:

Given that the activity in this TAM is completely flexible, it's impossible to specify what safety precautions should be taken. In general, the normal, safe operating procedures which apply to all industrial technology education laboratories are viable. This activity, in and of itself, does not call for any specific requirements for safety. A teacher, however, must remain alert to insure that any student activities engendered by this TAM are carefully thought through in terms of their safety implications.

Needed Materials:

1. **Supplies Required**
   - A. Graph paper - lightly ruled
   - B. Sketching pencils and Erasers

2. **Equipment/Machines/Tools**
   - A. Clipboard
   - B. Lego®, Fishertechnik, or other construction set

3. **Handouts**
   - A. Student component of TAM #2
   - B. Handout #1: Systems Theory Handout
   - C. Handout #2: Systems Analysis Worksheet

4. **Instructional Resources**
   - A. Catalogs
     1. Lego®, Fishertechnik, Erector Set or equivalent catalog showing all parts
     2. Resource catalogs describing the components of the kinds of systems that you will analyze

Management/Logistics:

1. **Related TAMS**

   Because this TAM describes a set of technological procedures that apply to any technology in any setting, this TAM can obviously be used to reinforce the kinds of activities found in all the other TAMS. More specifically, however, the activities described in this TAM are most useful in reinforcing problem solving and design activities elsewhere.

2. **Evaluation/Grading**

   The instructor should grade activities arising from this TAM based on their thoroughness and systematic nature, not on their complexity and/or obtuseness.

3. **Suggested Schedule/Time**

   This activity is so flexible it can be presented in one classroom session or become the heart of a major class project. As such, it is completely up to the instructor to allocate time. It would seem feasible, as a minimum, to spend one class period on each of the two major activities, mainly systems analysis and systems synthesis.

Key Instructional Suggestions:

1. **Safety**

   Note the previous comment regarding safety considerations in this TAM's instructor component. However, given the nature of the TAM, it becomes desirable to actually make an analysis of safety requirements of any TAM engendered activity and build that right into the assignment for analysis.

2. **Motivation**

   Try to excite students by pointing out how this process enables them to do two things. Number one, to identify what makes something tick -- something that they enjoy. Depending on the age of the student, use examples such as a Sony Walkman, high-tech audio systems for cars, car security alarms, hot rods, etc. Draw to the students' strengths, whatever they are interested in. If the environment happens to be one where 4-wheel drive vehicles and off-road competitions are common, use those. If the environment is predominantly agricultural, use analyses of irrigation systems or whatever.

3. **Prerequisite Information**

   There is no specific prerequisite information required for this TAM. It is completely self-contained.

4. **Demonstrations**

   A. With a student, walk through a systems analysis for a familiar activity, such as one of those highlighted in the motivation subsection above.

   B. Bring in a set of electronic modular components. Demonstrate how different systems can be integrated or developed from a basic set of building blocks of electric components. Alternatively, a good demonstration for this would be to bring in a person from a modular housing unit and have them show the variety of housing configurations that can be assembled out of a basic set of components.

5. **Reinforcement**

   This activity lends itself well to reinforcement of key concepts in all subject areas. For example, one could ask the English teacher to point out the relationships between words and grammar by demonstrating how those can be thought of as modules or components. Examples could be given to show that, when they are integrated in a variety of different ways, they communicate different messages. Similarly, the physics and science teacher should be in a position to highlight some key examples of molecular building blocks that can be combined to form different elements, i.e., systems synthesis. In the analytical mode, all teachers can identify how the basic concepts and skills in their area serve to reinforce and combine to enable all kinds of other operations to be performed. Even music can be used to show analysis in terms of tones and other key markings on the score sheet, as compared to integration of various combinations which result in alternative products. It is only the limits of the imagination that would hold back the reinforcement opportunities presented by this TAM.

6. Attitudes

There are two key attitudes that need to be fostered here. One takes its name from systems theory and that is the systematic approach. Inherently, one needs to get students to value doing a job very carefully from step one through the end step. They must do that in a way that is consistent and with a high degree of quality, i.e., so that all the bases have been covered and there are no glaring omissions. The second attitude that needs to be engendered is one of inquisitiveness, curiosity, and imagination. One needs to be comfortable enough to speculate and/or envision without fear of failing or being wrong. The teacher should address these attitudes head on and bring them to the attention of the students as being necessary corequisites for successful systems analysis and systems engineering activity.

7. Remediation/Enrichment

A. Remediation: Pair slower students having trouble grasping the concepts with more capable students and have the team do a systems analysis and/or synthesizing activity. Repeat this several times in order to ensure that each student has the opportunity to experience both sets of processes repeatedly.

B. Enrichment: Enrichment in this area primarily involves two strategies. The first deals with more complicated systems or higher order systems for analysis or synthesis -- things that are unusual or that students have not typically thought of but that are of high interest to them. For example, inertial guidance.

The second strategy demands more from the students. Here, on the systems analysis side, we expect them to detail things more, take a more quantitative approach to energy in versus energy out and control system dynamics such as oscillation hunting and the like. On the systems synthesis side we expect them to work out things in greater detail and produce a more complete specification of the solution.

8. Summary & Review

A. Systems terminology

1. Input
2. Process
3. Output
4. Feedback
5. Environment
6. Open system
7. Closed system
8. Subsystem
9. Suprasystem
10. Unit
11. Component

B. Systems Analysis
   1. Energy analysis
   2. Structural analysis
   3. Control analysis
   4. Processing analysis
   5. Structure analysis

C. Systems Engineering/Synthesis
   1. Blackbox approach
   2. Design specification
   3. Component configuration
   4. Hand-off mechanisms

9. Review Questions & Answers

A. What is the relationship of a system to: its suprasystem? its subsystem?

A suprasystem houses a system of concern or one that is being investigated and a subsystem is a part of the system being investigated.

B. Sketch a basic systems model on the board.

The answer involves a set of inputs to a processing function generating a set of outputs being monitored by a feedback loop, all of which operate within a context or environment.

C. Name the two major processes involving systems theory.

Systems analysis
Systems synthesis/engineering

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #2: Adventures with Systems Analysis - Pre-test

Instructions:

1. Identify three ways systems are used in industry:

   A. ____

   B. ____

   C. ____

2. Name the five key parts of all systems:

   A. ____

   B. ____

   C. ____

   D. ____

   E. ____

3. The identification of a system's parts is called:
   A. Systems synthesis
   B. Systems engineering
   C. Systems building
   D. Systems factoring
   E. Systems analysis

4. One of the best ways to test a system's effectiveness is to evaluate its':
   A. Input
   B. Processing
   C. Output
   D. Feedback
   E. Environment

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Date: ________ Class: ________ Name: ____________________________

TAM #2: Adventures with Systems Analysis - Pre-test

Instructions:

1. Identify the following parts of a satellite tracking/locating system:
   - A. Suprasystem
   - B. Subsystem
   - C. Units
   - D. Components (of one larger entity)
   - E. Feedback

2. Describe how you would use a Lego§ or Fishertechnik construction set to do "systems synthesis".

3. The assessment of a system's output and then the correction of its operation is a use of:
   - A. Environment
   - B. Throughput
   - C. Context
   - D. Feedback
   - E. Amplification

TAM #2: Adventures With Systems Theory - Test Keys

TAM #2 - Pre-test Answers

1. Instructor judgment
2. Instructor judgment
3. E
4. C

TAM #2 - Post-test Answers

1. Instructor judgment
2. Instructor judgment
3. E

TAM #2: Adventures With Systems Theory

Student Component

Introduction:

How can we possibly expect to stay on top of the thousands of new technological devices and systems that emerge every year? The answer is you can't --unless, of course, you are a capable master of a powerful set of tools. The purpose of this TAM is, in fact, to introduce you to such a set of tools and to allow you to develop the kinds of skills that you will be able to apply to any technological arena, regardless of your special interests. The name of this set of tools is called systems theory and, more specifically, it includes two key processes: 1) systems analysis, and 2) systems synthesis/engineering.

Competencies:
Following the completion of this TAM, you will be able to:

1. Define systems terminology according to the glossary presented in this TAM.
2. Take an unfamiliar system and identify the subsystems and their component parts within it.
3. Identify environmental and feedback mechanisms of existing systems.
4. Describe failings of current systems found in the industrial and environmental world in terms of systems theory. To design a new system using existing components.
5. Use an existing set of system components and build a new system out of it.
6. Sketch a block diagram to represent an actual system and its components.

Module Overview:

This module introduces you to systems analysis and systems synthesis/engineering. These two powerful skills will enable you to work with technology in all of its manifestations. Furthermore, you can successfully apply them to any problem-solving situation you encounter.

Systems theory is a powerful tool. Learn it well and there is very little you won't be able to understand, to explain, to plan. Applied to technological problems, this theory guides your problem-solving and increases the odds of your success!

Key Information:

1. Class Presentations

- Systems terminology

  A. Input
  B. Process
  C. Output
  D. Feedback
  E. Context
  F. Environment
  G. Open system
  H. Closed system
  I. Subsystem
  J. Suprasystem
  K. Unit
  L. Component

- Systems Analysis
  - A. Energy analysis
  - B. Structural analysis
  - C. Control analysis
  - D. Processing analysis
  - E. Structure analysis

- Systems Engineering/Synthesis
  - A. Blackbox approach
  - B. Design specification
  - C. Component configuration
  - D. Hand-off mechanisms

2. Demonstrations

- Walk through a systems analysis of a familiar activity such as one of those highlighted in the motivation subsection above.
- Bring in a set of electronic modular components and demonstrate how different systems can be integrated or developed from a basic set of building blocks of electric components. Alternatively, a good demonstration for this would be to bring in a person from a modular housing unit and have them show the variety of housing configurations that can be assembled out of a basic set of components.

3. Safety

Given that the activity in this TAM is completely flexible, it is impossible to specify what safety precautions are viable other than the normal safe operating procedures that apply to all industrial technology education laboratories. This activity, in and of itself, does not call for any specific requirements for safety. A teacher, however, must remain alert to ensure that any student activities engendered by this TAM are carefully thought through in terms of their safety implications.

4. Personal Activity

A. Go to a library and review any quality encyclopedia's definition of systems theory and systems analysis. Prepare a one paragraph summary of encyclopedia definitions for each key concept.

B. While at the library, review the card index for the words "systems theory" under any subject matter index in your library, or, ask the librarian to do a computer search for the term systems theory or systems analysis.

C. Identify any magazine or book that clearly lays out systems theory and/or analysis. A good one is "How Things Work."

Glossary:

1. **Closed System** -- A system that, for purposes of simplification, is not considered to interact with its environment.
2. **Component** -- A part of a unit.
3. **Context** -- A synonym for environment.
4. **Environment** -- The overall context or setting in which a system operates.
5. **Feedback** -- Assessment of a system's output for the purpose of controlling the system's operation.
6. **Input** -- A resource used by the system.
7. **Open System** -- A system that interacts with the environment.
8. **Output** -- The products or results of a system's processing.
9. **Process** -- How a system manipulates one or more inputs.
10. **Subsystem** -- A major part of a system.
11. **Suprasystem** -- A system formed by combining several systems into a larger one.
12. **System** -- A set of components, interacting for a purpose, yielding an output. Systems operate in a contest environment, and their output is assessed to give feedback to better control the system's operation.
13. **Unit** -- A major part of a sub-system.

Needed Materials:

1. **Supplies Required**
   - A. Graph paper - lightly ruled
   - B. Sketching pencils and erasers

2. **Equipment/Machines/Tools**
   - A. Clipboard
   - B. Lego®, Fishertechnik, or other construction set

3. **Handouts**
   - A. Student component of TAM #2
   - B. Handout #1 - Systems Theory Handout
   - C. Handout #2 - Systems Analysis Worksheet

TAM #2: Adventures in Systems Theory

Activity #1: Systems Analysis - Plan of Procedure

1. Pick any of the systems identified by the teacher. Sample systems include: Satellite Tracking, Star Wars, Subway, Automated Manufacturing, Submarine, Disc-man.
2. Investigate and research as much as you can about the system.
3. Write a statement that presents the system's purpose in a way that lay people can understand.
4. Make a chart/diagram showing the entire system's parts.
5. Show how the system's parts are grouped into subsystems and/or units.
6. Develop a table that shows the input and output of each unit and/or subsystem.
7. List the feedback methods used to evaluate each unit's outputs.
8. Use the overall system chart to explain the operation of unknown parts of the system in terms of what they must do in order to have the whole system work.
9. Describe the system's interactions with its environment/context.
10. Explain how you would trouble-shoot the system.
11. Now the teacher will demonstrate an unknown system (black box, e.g., a radar gun) to the whole class. Only the input and output can be revealed to students -- but only if they ask.
12. Students may ask questions about the system's inputs and outputs.
13. Students may look over the system, but they may not open it up to identify its components.
14. Students must speculate what components are needed and how they interact to have the system work as it does.
15. After the unknown system is charted, the instructor will reveal its make-up.
16. Discussions comparing student speculations and reality should explore why the differences occurred.

TAM #2: Adventures in Systems Theory

Activity #2: Systems Synthesis - Plan of Procedure

1. Form the class into small groups of a maximum four people each.
2. Place a mitten over either the right or left hand of each person in each group. Mix up which hands are in mittens.
3. Give each group an identical set of Lego® or Fishertechnik or other construction set.
4. Assign a scenario, e.g., use the components to build a machine that will move you from one island to another, to protect yourselves from marauding savages, or to build an energy converter.
5. Members in each group will then try to assemble their components into the most effective system that accomplishes the assigned goal.

   NOTE: Members can work only with their free (un-mittened) hand.

   NOTE: There is to be no interaction among the groups.

6. After a fixed time, groups are to present the results of their systems engineering/synthesis and explain how their system meets the design requirements.
7. The class as a whole should then discuss the differences between activities 1 and 2.

TAM #2 - Summary

1. **Review & Summary Activities**
   - A. Apply systems analysis to a new "Black Box" and identify the system's components.
   - B. Do a case study of a famous systems engineering project.
2. **Review Questions -- Test yourself!**
   - A. What is the key factor in systems engineering?
   - B. Why is feedback important?
   - C. How can feedback be used in systems?
   - D. Name two examples of open and closed systems and the advantages/disadvantages of each.

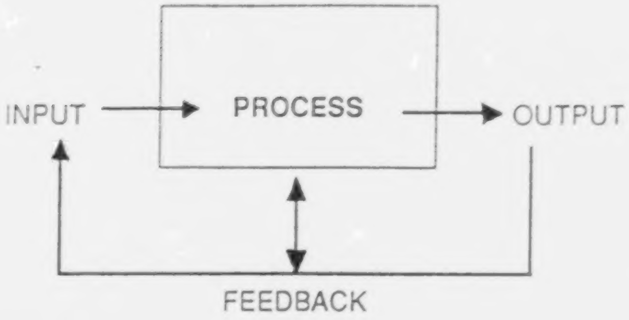
TAM #2 - Post-assessment

Instructions:

- A. Review your work for this TAM.
- B. Have the teacher check your work and record a grade.
- C. Take the post-test.

TAM #2 - Handout #1

Systems Theory



Systems are extremely simple when one masters the basic theory. Note the figure above. All explanations will refer to, it and its labels are described in this TAM's glossary.

1. All systems use one or more kinds of inputs. Examples of input are: people, energy, information, air, and more.

2. Systems take this input and process it (or some of it) in some way. Examples of processing include: refining, analyzing, building, and communicating. Some of the inputs themselves may be processed while other inputs may actually do or fuel the processing.

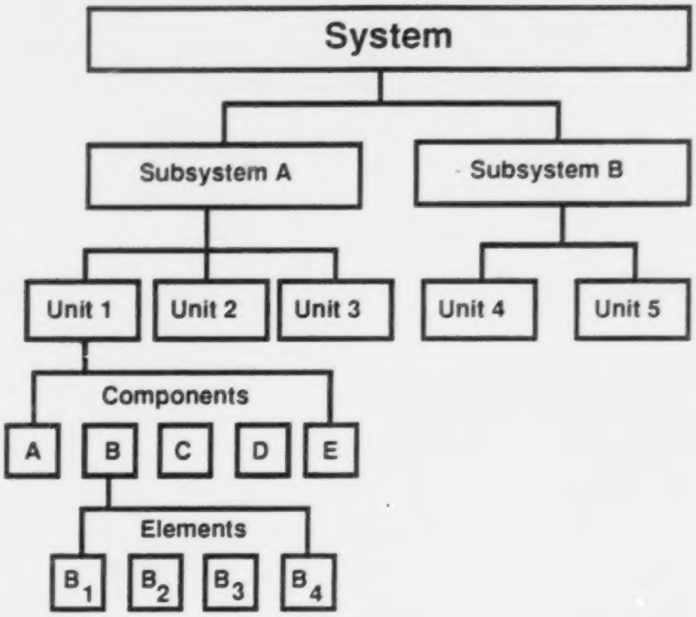
3. All systems then produce output. Examples of output include: energy, e.g., heat, waste, a product, or a message. Output is why systems exist. It is purposeful in that systems are designed to generate outputs.

4. System operations and output are monitored using feedback. This is simply the process of evaluating the operations and output to ascertain whether the output is of the right quality and/or quantity. This also provides a mechanism for evaluating the efficiency of the process.

5. All systems operate in an environment or context. For example, transportation systems, such as Missouri's railroads, operate within the environment of America's railroad system.

6. Systems that exchange inputs and/or output with their environment are called open systems. When, for purposes of simplification, we consider a system not to interact in any way with its environment, we call it a closed system. Note that in the real world there are no closed systems. However, sometimes they are useful for exploring things that would be too complex otherwise.

7. Systems also have another important characteristic in terms of their construction. Any system could be analyzed to identify the parts that make it up. For example, a system could easily consist of two or more subsystems.


System
Subsystem A
Subsystem B
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Components
A
B
C
D
E
Elements
B_1
B_2
B_3
B_4

- Sub systems in turn consist of two or more units.
- Units in turn consist of two or more components
- Components in turn consist of two or more elements.

8. Furthermore, systems also stack within one another. Just as any system contains many subsystems, units, components, and elements; the system as a whole can be a subsystem of a larger system. This larger system is called a suprasystem.

   Using the example we started in point 5, Missouri's railroad system is a subsystem in Missouri's transportation system, which is the suprasystem. Similarly, Missouri's transportation system is a subsystem in the nation's transportation system.

TAM #2 - Handout 2

Systems Analysis Worksheet

1. Write a paragraph describing the system to be analyzed.

2. List this system's:

	Inputs	Output
A. Subsystems		
B. Each subsystem's units		
C. Each component's elements		
C. Overall system		

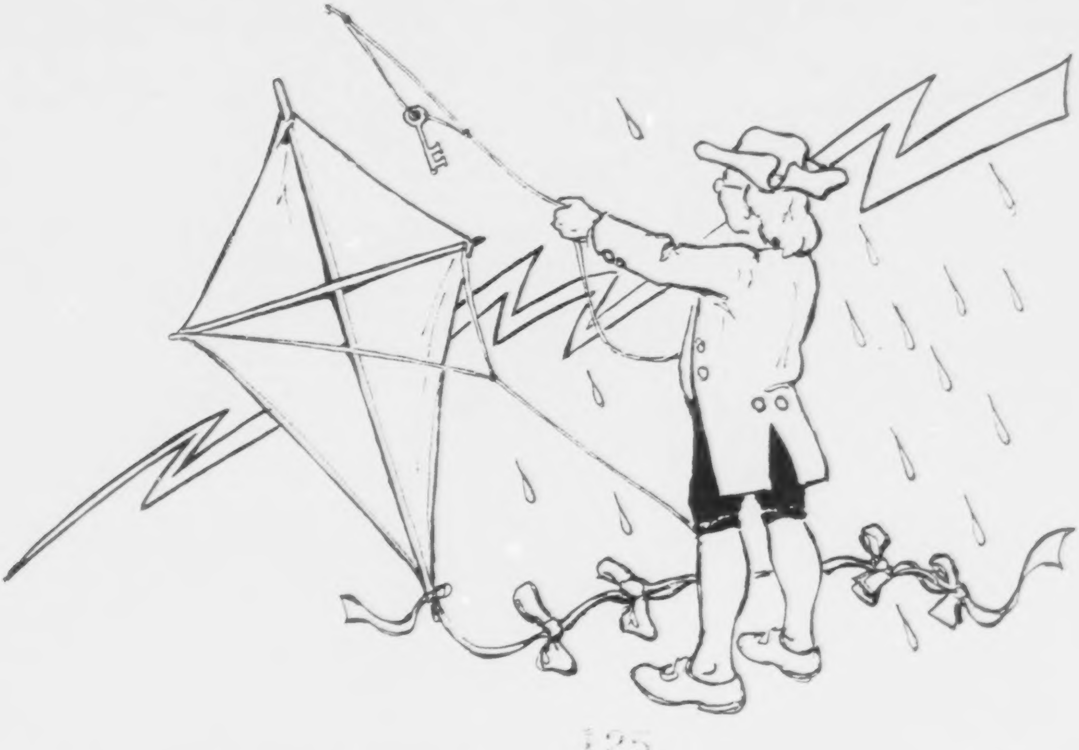
3. Go back to #2 and list each entity's inputs and outputs for each subsystem, unit, and component, as well as for the overall system..
4. Describe the system's most important feedback mechanism.
5. Describe the system's context or environment.
6. On the back of this page, draw a chart that illustrates all of the above data.

Course:	Introduction to Energy & Power Technology

Technology Activity Module #3

Designing and Conducting Experiments

by: Yusuf Al-Hassan



TAM #3: Designing & Conducting Experiments

Instructor Component

Activity Objectives: The purpose of this activity is to acquaint students with systematic procedures involved in experimental design. The key processes to be included are: designing experiments, conducting experiments, and technical reporting.

Activity Competencies: By completing this TAM, the student will be able to:

1. Process technological information using data analysis and data reduction methods such as computer or manual statistical process control procedures.
2. Report technological information using graphic, chart, tabular and textual presentations in printed, media or electronic forms.
3. Employ individual and group problem-solving processes to technological problems.
4. Use various technical means of data acquisition to process information about the operation of a technical system.
5. Use a variety of sketching techniques to analyze and communicate how a selected existing technical device or system functions.
6. Identify the role of experimentation and innovation in the development of energy-related technical advances.

Module Instructions

Introduction:

This activity is designed to expose students to designing and conducting experiments, including technical reporting. To be valid, these deductions must be able to be tested and repeated in other laboratories. It is suggested that this activity be incorporated into an appropriate classroom presentation of technological procedures. The proposed activities include experiences with designing, conducting and reporting on experiments.

Safety Considerations:

The safety requirements will vary for this TAM. Whenever students are engaged in experimental processes, it is important that the instructor build safety checkpoints.

Needed Materials:

1. Supplies Required
    A. Power supply
    B. Switch

C. Ammeter
D. Copper wire
E. Materials as needed to conduct experiment as designed

2. Equipment/Machines/Tools

A. Volt-Ohm-Milliampere (VOM) meter

3. Handouts

A. Student component of TAM #3
B. Handout #1: Experimentation Information
C. Handout #2: Basic Principles of Good Technical Writing

4. Instructional Resources

A. Books

1. Beeter, N.F. & Brauley, F.M. (1955). Experiments in science (pp. 1-28). Binghamton, NY: Vail-Ballou Press.
2. Gerrish, H.H. & Dugger, W.E., Jr. (1980). Electricity and electronics (pp. 28-48). South Holland, IL: Goodheart-Willcox Company, Inc. ISBN 0-87006-284-0
3. Kaplan, B.H. (1983). Problem solving in biology (pp. 205-221). New York, NY: MacMillan Publishing Company. ISBN 0-02-362050-1
4. Katz, P.S. (1980). The technical research paper for two-year students. Engineering Education, pp. 809-812.
5. Mills, G.H. & Walter, J.A. (1966). Technical writing, revised edition (pp. 1-128). New York, NY: Holt, Rinehart and Winston, Inc.
6. Tortra, T.J. & Adams, H.H. (1989). Laboratory exercises in human physiology (pp. 4-5). New York, NY: MacMillan Publishing Company. ISBN 0-02-421203-2
7. Wyler, R. (1952). The first book of science experiments (pp. 7-9 & 12-24). New York, NY: Franklin Watts, Inc.

Management/Logistics:

1. Related TAMS

This TAM is related to TAM #2 - Problem-solving, in the Materials and Processing Guide. Also, skills developed in technical writing and systematic thinking are indirectly related to most other TAMs.

2. Evaluation/Grading

Evaluation and grading should occur at several levels. The technical writing process will focus on the reinforcement of English composition skills. Evaluation of the experimental design process should focus on both the process and the product.

3. Suggested Schedule/Time

One to two weeks are suggested for this activity.

Key Instructional Suggestions:

1. **Safety**

   Remind students of basic laboratory safety procedures. It will be appropriate to discuss safety in the context of experimentation. In many cases, the experimental process involves processes or procedures that may have unpredictable results. Students need to learn how to think these through. For the purposes of instruction, be sure to build in consistent checkpoints prior to students engaging in experimental activities to ensure safety.

2. **Motivation**

   One of the strengths of this TAM is that it is adaptable to student interests. Some of the possible projects and experiments are: demonstrating an electric circuit or a simple switch, determining the effect of heat on a liquid, demonstrating the principles of the thermostat, etc. Encourage students to pursue their interests.

3. **Prerequisite Information**

   The amount of prerequisite information required for this TAM will depend largely on the kind of experimental process that students choose. One of the opportunities of the activity is to help students assess their knowledge level. Students will tend to either underestimate or overestimate what they know. This kind of activity is also a useful way of helping students learn how to access information they don't have yet. Be sure to describe the concept of resistivity so that all students know what it is.

4. **Demonstrations**

   It will be useful for the instructor to demonstrate a model experimental design process from beginning to end, including illustrations of the technical reporting process.

   Note: The following diagram represents one possible experimental setup to solve the problem assigned in Activity One. Do not reveal this solution prematurely--it would be better to have students design their own setup (Figure #1).

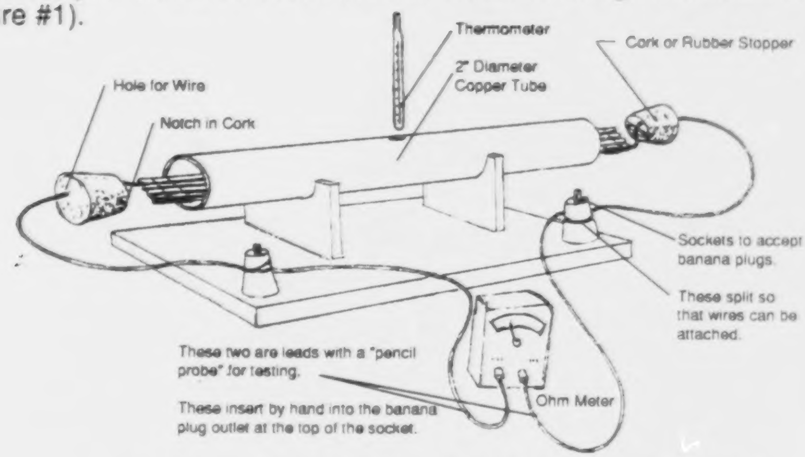

Thermometer
Cork or Rubber Stopper
2" Diameter Copper Tube
Hole for Wire
Notch in Cork
Sockets to accept banana plugs.
These split so that wires can be attached.
These two are leads with a "pencil probe" for testing.
These insert by hand into the banana plug outlet at the top of the socket.
Ohm Meter

Figure #1 - Sample Resistivity Experimental Setup

5. **Reinforcement**

   The nature of this TAM provides an opportunity to reinforce English composition and science skills and concepts. These include research, scientific methodology, principles of technology, and review of literature.

6. **Attitudes**

   Students often underestimate their knowledge and their ability to be creative. It will be important to provide a balance between assisting students and encouraging them to think through the process for themselves.

7. **Remediation/Enrichment**

   A. Remediation: It will be useful to group students according to ability and interest ranges.

   B. Enrichment: Students should engage in an advanced level experimental design procedure process.

8. **Summary & Review**

   Summarize the steps involved in the experimentation and design process:

   A. Hypothesis (how to generate it)
   B. Experiment
   C. Tests
   D. Scientific method and its steps
   E. Variables (dependent and independent)
   F. Abstract
   G. Results
   H. Discussion/conclusion
   E. Basic principles of good technical writing
   J. Technical writing skills

9. **Review Questions & Answers**

   A. What is the first step to be followed when conducting an experiment?

   Observe something carefully and then begin to formulate the questions that come to mind.

   B. What are the basic principles to keep in mind when doing technical writing?

   Keep your reader in mind.
   Clearly define your purpose.
   Keep the language as simple as possible.
   Make the report attractive.

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #3: Designing and Conducting Experiments - Pre-test

Instructions: Fill in the blank spaces below with the correct words.

1. The initial stage in the experimental design process is the formulation of a(n) ________________.

2. The scientific method is the process through which ________________ are made.

Instructions: Circle the letter that correctly completes the sentence.

3. Choosing a sample size involves the selection of:
   A. The number of subjects
   B. A statistical test
   C. An experiment
   D. Variation across the sample

4. A population size is the number of:
   A. Subjects to be tested
   B. Statistical tests to be tested
   C. Experiments to be tested
   D. Total number of subjects in the group being studied

5. A null hypothesis is a testable experimental question which:
   A. Is stated in terms of what the researcher would logically expect to occur
   B. Is the hypothesis which is accepted when it becomes clear that the real hypothesis should be rejected
   C. Is based on some well-established positions that should not be rejected unless there is considerable evidence to the contrary
   D. Identifies the total number of subjects you are testing

Date: ________ Class: ________ Name: ____________________________

TAM #3: Designing and Conducting Experiments - Post-test

1. A hypothesis is:
   - A. An educated guess about the outcome of an experiment
   - B. An unproven conclusion
   - C. A test used in seeking the right answer to a question
   - D. A & B
   - E. B & C

2. In generating experimental scenarios, the following should be identified:
   - A. Dependent and independent variables
   - B. Constant and control
   - C. Repeated trials & hypothesis
   - D. All of the above

Instructions: Answer each question in the space provided.

3. List and describe at least four issues that should be addressed when planning and conducting experiments.

4. Explain the differences between conducting an experiment and designing an experiment.

5. What is a technical reporting? What purpose(s) does it serve?

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TAM #3: Design and Using Experiments - Test Keys

TAM #3- Pre-test Answers

1. Hypothesis
2. Deductions
3. A
4. D

TAM #3 - Post-test Answers

1. A
2. D
3. (a) What are the characteristics of the materials that are being used for conducting the experiment (e.g., aluminum and steel, both of which transfer heat at different rates)?

   (b) What happens to the materials during the process of conducting the experiment (e.g., finding that aluminum transfers heat more rapidly than does steel)?

   (c) How can the parameters of the experiment be manipulated to affect the outcome (e.g., by changing the heat of one or both of the metals)?

   (d) How can you describe the change that took place as a result of the changes?
4. The process of design involves planning the process, including such factors as materials selection, identification of key variables, planning for variable control, etc. Conducting experiments involves the systematic and careful implementation of the procedures outlined in the design process.
5. Technical reporting essentially consists of a careful and detailed documentation of both the experimental design and implementation processes.

TAM #3: Design and Using Experiments

Student Component

Introduction:

What comes to mind when you think of experiments? Do you picture laboratories full of test tubes, wires running everywhere, bubbling solutions, and wild-eyed people in white coats? That's not the whole picture. Experiments happen all the time in a variety of situations. Some are very scientific, like testing rocket fuels and new composite materials for computer chips. Others are so commonplace we don't even think of them. Think, for example, about tinkering with the timing in your car, or even tasting your food. Industrial Technology Education is full of possibilities for experimentation. This TAM is designed to show you how.

Competencies: Following the completion of this TAM, you will be able to:

1. Process technological information using data analysis and data reduction methods such as computer or manual statistical process control procedures.
2. Report technological information using graphic, chart, tabular and textual presentations in printed, media or electronic forms.
3. Employ individual and group problem-solving processes to technological problems.
4. Use various technical means of data acquisition to process information about the operation of a technical system.
5. Use a variety of sketching techniques to analyze and communicate how a selected existing technical device or system functions.
6. Identify the role of experimentation and innovation in the development of energy-related technical advances.

Module Overview:

This module contains several different activities dealing with experimentation. Some of the activities will be spelled out for you with quite a lot of detail. Other activities will require you to come up with your own ideas.

Ever wonder about how something works? The purpose of this TAM is to provide you with a systematic procedure for figuring those things out. If you get stuck or discouraged, that's okay. Just check with the instructor. Getting stuck is part of what experimentation is all about. Otherwise, what would be the point of experimenting at all?

This TAM consists of a series of experimental activities. The procedures can be adapted to work, almost as a life-style or way of thinking, with lots of Energy&Power-related activities.

Key Information:

1. Class Presentations

The instructor will present several different kinds of information. Some will be designed to demonstrate the experimental method. Some readings will be assigned. Some of what will be presented will depend on what direction you decide to go with your experiments. There will be some times when you will be asked to present what you're doing to the class.

2. Demonstrations

These will be presented as they become necessary during the activities. If you get stuck or don't know what to do next, ask the instructor.

3. Safety

The same general safety procedures hold for this activity as for all Industrial Technology Education lab activities. When experimenting with things, safety is especially important. If there is a question in your mind as to whether a process or procedure is safe or not, have the instructor check it out for you.

4. Personal Activity

- Read the assigned readings.
- Review the procedure for the experimental method.

Glossary:

1. **Abstract** -- A brief, concise summary of the major findings of the study.
2. **Alternate Hypothesis** -- A different hypothesis that suggests other possibilities than the primary hypothesis about the relationship of variables in which you are interested.
3. **Control Group** -- A group that is similar to the experimental group in all respects except for the manipulated variable.
4. **Dependent Variable** -- The variable that responds to the experiment's manipulation.
5. **Experiment** -- A test used in seeking the answer to a question.
6. **Hypothesis** -- An unproven conclusion or an educated guess about the outcome of an experiment.
7. **Independent Variable** -- The variable that is manipulated or changed by the experimenter.
8. **Laboratory** -- A workshop equipped for science or technological experiments.
9. **Null Hypothesis** -- An exact, experimental question which is stated in a negative form and which can be tested.
10. **Polarity** -- A property or device or circuit that has poles, such as North and South or positive and negative.
11. **Sample Size** -- The number of subjects to be tested.
12. **Scientific Method** -- The process through which deductions based on observations are made.
13. **Sensitivity** -- The ability of something to respond to small signals.
14. **Technical Writing** -- Writing which consists of a relatively high concentration of certain scientific and/or technological processes.
15. **Thermocouple** -- A device based on the principle that if two different metals are welded together and the junction is heated, a D.C. voltage will develop across open ends.
16. **Variables** -- Factors that affect the outcome of the experiment.
17. **Volt-Ohm-Meter** -- A portable multimeter for measuring voltage.
18. **Voltage** -- An electron tube used to amplify a voltage.
19. **Voltmeter** -- An instrument used to measure voltage.

Needed Materials:

1. **Supplies Required**
   - A. Power supply
   - B. Switch
   - C. Ammeter
   - D. Copper wire
   - E. Materials as needed to conduct experiment as designed

2. **Equipment/Machines/Tools**
   - A. Volt-Ohm-Milliampere (VOM) meter

3. **Handouts**
   - A. Student component of TAM #3
   - B. Handout #1: Experimentation Information
   - C. Handout #2: Basic Principles of Good Technical Writing

TAM #3: Designing & Conducting Experiments

Activity #1: Measuring Resistivity - Plan of Procedure

1. Design an experiment that would identify the resistivity of a material such as solid copper wire.

Resistivity: A constant value for different materials. Resistivity is directly proportional to the length and inversely proportional to the cross-sectional area of the metal. The value of resistivity of a material depends only on the material and temperature.

Computation:

$$R = \frac{\rho \times L}{A}$$

$$\rho = \frac{R \times A}{L}$$

where:
R = Resistance in Ohms
L = Length in inches
A = Area in square inches
ρ = Resistivity constant in ohms/in.
(Note: ρ [rho] is the Greek symbol for resistivity)

2. There are several possible solutions to this problem. Choose one solution to this problem and explain the reason for this choice.

3. Design and sketch an experimental setup necessary to secure the data needed to calculate resistivity for any given material.

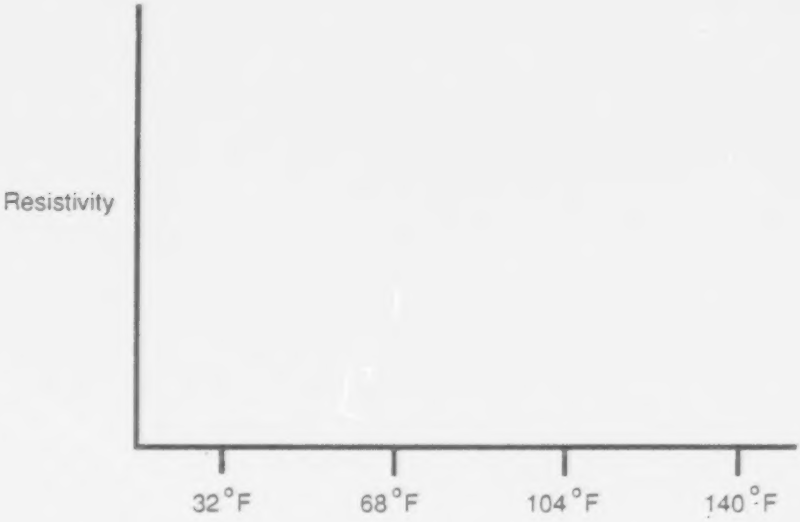
Hint:
- Use only one commonly available material, e.g., copper wire.
- Use long lengths of wire to maximize measurable effects.
- Use material samples with greatly varying diameters, but be sure the material's chemical composition remains the same, i.e., use the same brand or alloy.
- Use a precision ohmmeter.
- Keep the temperature controlled to 70 degrees.

4. Collect data to fill this table.

	Material	Length	Diameter (to .001")	Measured Ohms	Calculated Resistivity
Sample #1					
Sample #2					
Sample #3					

5. Redesign the experiment to identify the relationship between resistivity and temperature for the same material you tested in steps 3 and 4.

6. Plot the data secured in step 5.



7. Write a draft report describing the experiments you designed and conducted.

TAM #3: Design and Using Experiments

Activity #2: Technical Reporting - Plan of Procedure

Technical report writing involves putting down on paper what you did, why you did it, and what happened as a result. This is more important than you might think. Most of us do not remember as well as we think we might. Once it's written down, then the material is there to refer back to. In general terms, technical reporting is composed of the following sections:

1. Reviewing the report that you drafted for activity one. Revise it to include all of the components listed in the outline below.

A. Title: This is a "handle" to let the reader know what the topic is.

B. Introduction
- A brief overview of the topic
- Include short quotes or paraphrases of material you've read on the topic
- This part should be very general

C. Problem Statement
- A brief statement of what question(s) your experiment is designed to answer
- What is the goal of your experiment or activity?

D. Materials and Equipment Used
- A brief and concise description of the equipment used
- A description and listing of material used

E. Methods
- Procedure
  - -What did you do and how did you do it?
- Analysis
  - -How did you analyze what happened? visual observation? statistical procedures? etc.?

F. Results
- Designed to show how the experiment or procedure addressed the problem outlined in the problem statement
- Include all data
- Describe the results
- State any trends that you might have found
- Make a table or some kind of visual display

G. Conclusion(s)
- The first paragraph should summarize major findings of the experiment
- Each subsequent paragraph should follow the first one, dealing in turn with one of the major findings of the experiment
- Interpret the results in the light of your experiment
- The conclusion should tie with the introduction

2. Preparing, preferably using a word processor and graphic program, a final clean copy of your experiment's technical report.

TAM #3 - Summary

1. **Review & Summary Activities**

   The activities in this TAM provide you with an enormous challenge. There is no doubt they will also help you broaden your knowledge as well as your experience in sciences and industrial technology, which invariably builds a base that is of importance to you.

   You have to remember that your approach to the activities in this TAM is very important. Your attitude and characteristics towards the activities you perform and the effort you put in will surely determine how much you will learn about new technological developments.

2. **Review Questions -- Test yourself!**

   A. Define a scientific method of conducting an experiment and list the steps.

   B. How can you distinguish dependent and independent variables in an experiment?

   C. How do you generate a hypothesis?

   D. Before you begin a technical writing, what are the steps you should take?

   E. What are the key concepts for practice in experimental design?

   F. Describe the importance of four question strategy.

   G. Explain the importance of producing a quality piece of writing.

TAM #3 - Post-assessment

Instructions:

1. Complete the self-check on design, conducting the experiment and technical reporting processes you have performed.
2. Have the instructor complete the evaluation and discuss discrepancies between the two assessments.
3. If your results demonstrate mastery, go on to the next TAM or activity as it may be assigned by your instructor. If, however, your results are less than completely successful, see your instructor and plan what to do to raise your level of mastery.
4. Complete the post-test self-check and have the instructor complete the evaluation, then discuss any discrepancies between the two assessments.

TAM #3 - Handout 1

Experimentation Information

Five Steps for Experimenting

1. Identify experiment components.
2. Design the experiment.
3. Establish control and experimental groups.
4. Conduct experiments and collect data.
5. Analyze data and interpret results.

Designing and Conducting Experiments

1. The first step in experimentation is to decide what the purpose of your experiment is. What are you testing, trying to find out, etc.? (For example, does aluminum transfer heat more rapidly than steel?)
2. Identify the variables. Usually, there are four types: independent, dependent, control, and error. The dependent variable is affected by the independent and error variables. Control variables are held constant or otherwise regulated in a manner known to the researcher.
3. State the hypothesis - what do you expect is going to happen?
4. State an alternative hypothesis - if your first hypothesis doesn't happen, what do you think is going to happen instead?
5. Design the experiment. What are you going to do and how are you going to do it? Suggestions that can help in this process include:
   A. Getting suggestions from your teacher or a friend.
   B. Examining all factors which might bias your results to favor any of your alternate hypotheses.
6. Do the experiment:
   A. Follow the procedures that you established earlier.
   B. Collect appropriate data.
7. Analyze the results:
   A. What happened?
   B. What didn't happen?
8. Interpret data or test results:
   A. What are your conclusions?
   B. What did you learn from the experience?

Handout #1 Continued

Experimentation Information

The following are the important considerations in designing experiments:

1. Learning to be clear about what you're trying to find out.
2. Setting up a control group.
3. Making sure you perform enough trials to know that it always happens the same.
4. Quality and appropriateness of the dependent variables.
    A. Measured variables
    B. Observed variables
5. Adequacy of time for the experiment and frequency of measurements.
6. Appropriate use of materials and equipment.

TAM #3 - Handout 2

Basic Principles of Good Technical Writing

There are twelve (12) basic principles of good technical writing:

1. While writing, have a specific reader or audience in mind.
2. Decide the purpose of your writing and have it reviewed by a knowledgeable person.
3. Use simple language as much as possible.
4. Inform your reader of what you want to tell them.
5. Be sure your report is attractive.
6. Move through the presentation in a logical manner.
7. Describe and define any unusual or unfamiliar terms.
8. Use headings and sub-headings to "frame" your material.
9. Have a friend read over your material to see if it is clear to him or her.
10. Make certain your conclusions are justified by your findings.
11. Acknowledge all sources you have used.
12. Include sketches, diagrams, and other artwork as necessary to convey meanings and ideas.

Course: Introduction to Energy & Power Technology

Technology Activity Module #4

Technology Assessment Process

by: Yusuf Al-Hassan

RECYCLING PRODUCTS
OIL
GLASS
PAPER

Instructor Component

Activity Objectives: The purpose of this activity is to expose students to the effects of the introduction, extension, or modification of technology. Special emphasis is given to delayed impacts in a wide range of activities. The areas students will encounter include technology assessment processes and the application of those processes to a local situation, such as recycling.

Activity Competencies: By completing this TAM, the student will be able to:

1. Develop a detailed list of a technological system's major building blocks, system and building block inputs, system and building block outputs, a statement of the systems goal, and it's feedback mechanism. The student should also be able to prepare a statement of the system's goal, identify its feedback mechanism, and sketch the system's configuration.
2. Design a technological system using existing and/or newly developed components and/or building blocks to meet an assigned set of design specifications.
3. Process technological information using data analysis and data reduction methods such as computer or manual statistical process control procedures.
4. Report technological information using graphic, chart, tabular and textual presentations in printed, media or electronic forms.
5. Employ individual and group problem-solving processes to arrive at, assess, and, subsequently, implement alternative solutions to assigned technological problems.
6. Conduct technology assessment studies to evaluate the impacts and benefits of a specific technology or technological solution.
7. Assess the effects that power and energy technology has made and will make on society, human needs, the environment, and values.
8. Use various technical means of data acquisition to process information concerning the operation of a technical system.
9. Use a variety of sketching techniques to analyze and communicate how a selected existing technical device or system functions.
10. Identify the role of experimentation and innovation in the development of energy-related technical advances.
11. Describe the role of serendipity in the invention process.

Module Instructions

Introduction:

This activity is designed to make students aware of the various effects of introducing a new technology. Students should learn that one way to avoid serious side effects is to control both the speed and manner of implementing the innovation. This activity may be integrated with an appropriate classroom presentation of energy and power instrumentation and control. The activities in this module include: safety, pre-test, post-test, and demonstrations on how to apply the process to a local situation.

Safety Considerations:

The physical, biological, economic, social, and political effects of any technological application must be carefully considered and planned for in advance. Also, special attention should be given to the safe handling of crushing cans, including the melting and remelting of ingots.

Needed Materials:

1. **Supplies Required**

   As appropriate and necessary

2. **Equipment/Machines/Tools**
   - A. Crucible furnace
   - B. Ingot molds
   - C. Any other equipment needed for the design and construction of the can crusher

3. **Handouts**

   Student component of TAM #4

4. **Instructional Resources**
   - A. Books
     1. Daraio, M.G., Maisel, J. & Wade, C. (Ed.). (1973). Man and his technology (2nd ed.) (pp. 23-25 & 323-325). New York, NY: McGraw-Hill Book Company ISBN 0-07-019510-2
     2. Teich, A.H. (Ed.). (1973). Technology and man's future (2nd ed.) (pp.243-277). New York, NY: St. Matin's Press. ISBN 312-78995-5
     3. Dickey, J.W., Glancy, D.M., & Jennele, E.M. (1973). Technology assessment (pp.1-38). Lexington, MA: Lexington Books. ISBN 0-669-86876-0
     4. Coates, V.T. & Mock, J.E. (1974). The southern regional conference on technology assessment (pp.1-36). Atlanta, GA: National Science Foundation.
     5. Srinivasan, M. (Ed.). (1982). Technology assessment and development (pp.3-33, 55-92, 119-139, 161-171). New York, NY: Praeger Publishers. ISBN 0-03-059543-6

6. Rothman, H. (1975). Technology assessment (pp.1-33). New Delhi, India: Center for Study of Science, Technology and Development.
7. Holmes, J.R. (1975). Refuse recovery and recycling (pp. 1-9, 95-104). New York: Vail-Ballou Press, Inc. ISBN 0-471-27902-1
8. Barton, A.F.M. (1979). Resource recovery and recycling (pp.1-30, 99-110, 175-263). New York: Wiley-Interscience Publication. ISBN 0-471-02773-1
9. Noll, K.E., Haas, C.N., Schmidt, C., & Kodukula, P. (1985). Recovery, recycle and refuse of industrial waste (pp.23-31 & 75). Chelsea, MI: Lewis Publishers, Inc. ISBN 0-87371-002-9
10. Porter, R. and Roberts, T. (Ed.). (1985). Energy savings by wastes recycling (pp. 1-7 & 103-122). New York: Elsevier Science Publishing. ISBN 0-85334-353-5
11. Henstock, M.E. (Ed.). (1974). Recycling and disposal of solid waste (pp.1-15, 63-70, 100-123, 130-167, 181-184 & 203-217). Nottingham, England: University of Nottingham.
12. U.S. Department of Interior: Bureau of Mines. (1971). Effective technology for recycling metal (pp.6-9, 22-31, 55-58 & 70-77). New York, NY: National Association of Secondary Material Industries, Inc.

B. Film slides/film/video

Show an audio-visual program on technology assessment. Also, select an appropriate title from a film or video library.

C. Field trips

Visit a local recycling plant.

Management/Logistics:

1. Related TAMS

This TAM is independent, but could be linked to most others.

2. Evaluation/Grading

A. 50% Project Work
B. 50% Examination

3. Suggested Schedule/Time

The suggested completion time for this module is one week.

Key Instructional Suggestions:

1. Safety

The instructor should ensure that all safety procedures are fully reinforced; however, this will vary with the design and construction of the can crusher. Review with your students the safety procedures to be observed in the laboratory.

2. Motivation

Schedule a field trip to a local recycling plant.

3. Prerequisite Information

None.

4. Demonstrations

A. Constructing a can crusher.
B. Cutting the materials to size.
C. Machining the parts of the materials.
D. Welding the materials.
E. Melting and re-melting ingots.
F. Casting.

5. Reinforcement

A. Present the class with a film/video on technology assessment.
B. Take a field trip to a local recycling plant.

6. Attitudes

The key attitudes important to this TAM are care and concern about people's safety as well as the negative effects of technology on the environment.

7. Remediation/Enrichment

Remediation: Pair students finding this TAM difficult with other, more proficient, classmates. It will be wise for the instructor to keep these students' project simple.
Enrichment: Introduce advanced students to another recycling activity, such as paper, glass, etc.

8. Summary & Review

Summarize and review the following steps in the technology assessment process:

A. Define the assessment task.
B. Describe relevant technologies.
C. Describe the existing state.
D. Identify impact areas.
E. Formulate alternative objectives.
F. Identify action options.
G. Conduct impact analysis.
H. Recycling procedures.

9. Review Questions & Answers

A. Discuss the importance of recycling.

As the earth's population increases, the materials people use also increase, many of which are thrown away when people are finished with them. Used materials are sometimes burned or buried in land fills. Recycling is not only a way of using these materials several times, but prevents the necessity of stripping new materials from the earth.

B. What is the importance of technology assessment?

The importance of technology assessment lies in its attempt to control the development of technology so that serious side effects can be avoided.

C. What are the two broad fears which have been expressed about the results of technology assessment?

1. *Large corporations sometimes resist technology assessment because it may threaten economic development.*
2. *Many people are poorly informed about environmental concerns and issues.*

Date: ________ Class: ________ Name: ______________________________

TAM #4: Technology Assessment Process - Pre-test

Instructions: Fill in the blank spaces below with the correct word(s).

1. Recycling is the process of (A)______________ of discarded or (B)______ material.

2. Technology assessment is the systematic study of the (A) ______________ on (B) ____________ that may occur when a (C) ______________ is introduced, extended or modified, with special emphasis given to the (D)______________ that are unintended, indirect and delayed.

3. Some of the materials that can be used for recycling are: (name any four)

   A. ____
   B. ____
   C. ____
   D. ____

4. Technology assessment has seven steps - name any four of the seven.

   A. ____
   B. ____
   C. ____
   D. ____

Date: ________ **Class:** ________ **Name:** ______________________________

TAM #4: Technology Assessment Process - Post-test

Course: Introduction to Energy and Power Technology **Date:** ________

TAM #4 Title: Technology Assessment Process

Student Name: ____

Performance Rating Poor Excellent

TASK 1 2 3 4 5

The Steps

1. Did you define the assessment correctly? __:__:__:__:__
2. Did you describe the relevant technologies appropriately? __:__:__:__:__
3. Was the existing state described appropriately? __:__:__:__:__
4. Did you identify the impact areas? __:__:__:__:__
5. Was there any formulation of alternative objectives? __:__:__:__:__
6. Did you identify action options? __:__:__:__:__
7. Did you conduct the impact analysis appropriately? __:__:__:__:__

Recycling of Can Scrap

1. Did you assemble pertinent information thoroughly? __:__:__:__:__

7. Was the collection of the can scrap successfully done? __:__:__:__:__

3. Did you succeed in storing the can scrap in a safe place? __:__:__:__:__
4. Did you sort out cans appropriately? __:__:__:__:__
5. Did you succeed in designing and constructing a can crusher? __:__:__:__:__
6. Was the can smashing successful? __:__:__:__:__
7. Did you successfully melt the cans in a crucible and pour the ingot mold appropriately? __:__:__:__:__
8. Was the re-melting of ingots in the crucible furnace and casting them into a useable product(s) done successfully? __:__:__:__:__
9. Did you succeed in selling the useable product(s) to consumers? __:__:__:__:__

Total: ___

TAM #4: Technology Assessment Process - Pre-test Answers

1. A. Employing recovered material or utilizing one or more components
   B. Waste material

2. A. Effects
   B. Society
   C. Technology
   D. Impacts

3. Any of the following:
   A. Paper
   B. Can(s)
   C. Bottle(s)
   D. Automotive scrap
   E. Glass
   F. Ferrous metals
   G. Textiles
   H. Polymers
   I. Aluminum

4. A. Define assessment task
   B. Describe relevant technologies
   C. Describe the existing state
   D. Identify impact areas
   E. Formulate alternative objectives
   F. Identify action options
   G. Conduct impact analysis

TAM #4 - Post-test Answers

A rating scale form is used as a post-test.

TAM #4: Technology Assessment Process

Student Component

Introduction:

The technology assessment provides you with a means for evaluating the effects of industrial technology processes. This TAM will teach you that these procedures can be viewed like an airplane pilot's pre-flight checklist. No matter how normal or routine a flight, every pilot should run down the checklist before taking off or landing. In the same way, the assessment steps of procedure should be run through to make sure nothing is left out.

Competencies: Following the completion of this TAM, you will be able to:

1. Develop a detailed list of a technological system's major building blocks, system and building block inputs, system and building block outputs, a statement of the system goal, and it's feedback mechanism. The student should also be able to prepare a statement of the system's goal, identify its feedback mechanism, and sketch the system's configuration.
2. Design a technological system using existing and/or newly developed components and/or building blocks, to meet an assigned set of design specifications.
3. Process technological information using data analysis and data reduction methods such as computer or manual statistical process control procedures.
4. Report technological information using graphic, chart, tabular and textual presentations in printed, media or electronic forms.
5. Employ individual and group problem-solving processes to arrive at, assess, and subsequently implement alternative solutions to assigned technological problems.
6. Conduct technology assessment studies to evaluate the impacts and benefits of a specific technology or technological solution.
7. Assess the effects that power and energy technology has made and will make on society, human needs, the environment, and values.
8. Use various technical means of data acquisition to process information concerning the operation of a technical system.
9. Use a variety of sketching techniques to analyze and communicate how a selected existing technical device or system functions.
10. Identify the role of experimentation and innovation in the development of energy-related technical advances.
11. Describe the role of serendipity in the invention process.

Module Overview:

Humans have the ability to think and reason. However, the attitudes, values, interests, and time perspective of one person may not appear rational to others. Because of these factors, there is a need to incorporate technology assessment into the decision process of every community and local government agencies so that planning decisions can be made more rationally.

To ensure that an action option could work from a technical point of view, you should be able to analyze a technology system's effects and interactions. The consequences on individuals and groups can be evaluated. Important consequences include: environmental, economical, legal, institutional, psychological, political, social and technological.

Key Information:

1. **Class Presentations**
   - The seven major steps of technology assessment
   - Recycling procedures
2. **Demonstrations**
   - Construction of a can crusher
   - Casting ingots
   - Melting and re-melting ingots
3. **Safety**
   - Concern of negative effects of technology
   - Controlling the effects of technology on people's lives and environments
   - Following proper safety procedures in lab

Glossary:

1. **Direct Recycling** -- The use of recovered material for the manufacture of a similar product.
2. **House Waste** -- Wastes arising at individual dwellings, normally collected by local authorities.
3. **In-house Scrap** -- The non-product output of a manufacturing industry.
4. **Incineration** -- A method of waste treatment involving burning or oxidation of waste materials so that only ashes remain.
5. **Indirect Recycling** -- The use of salvaged material for the manufacture of a product of less critical specification.
6. **Industrial Waste** -- Wastes arising at an industrial plant during the manufacturing and processing of materials and also at later stages of product fabrication.
7. **Leaching** -- The process of dissolving a soluble constituent of a mixture into a suitable solvent.
8. **Reclamation** -- The process of segregating wastes from different locations and preparing them for sale or re-use.
9. **Recovery** -- The process of collecting homogeneous wastes for re-use.
10. **Recycling** -- The actual process of employing recovered material or utilizing one or more components (including chemical energy) of discarded or waste material.
11. **Re-use** -- The recovery process of a secondary material and its subsequent use in its original form for its original use.
12. **Salvage** -- The extraction of homogeneous waste material from a mixture of wastes.
13. **Technology Assessment** -- The systematic study of the effects on society that may occur when a technology is introduced, extended, or modified with special emphasis given to the impacts that are unintended, indirect and delayed.
14. **Thermal Recycling** -- The conversion of waste under conditions which generate either energy products, chemical products, or both.

Needed Materials:

1. **Supplies Required**

2. **Equipment/Machines/Tools**
   - A. Crucible furnace
   - B. Ingot molds
   - C. Any other equipment needed for the design and construction of the can crusher

3. **Handouts**

   Student component of TAM #4

TAM #4: Technology Assessment Process

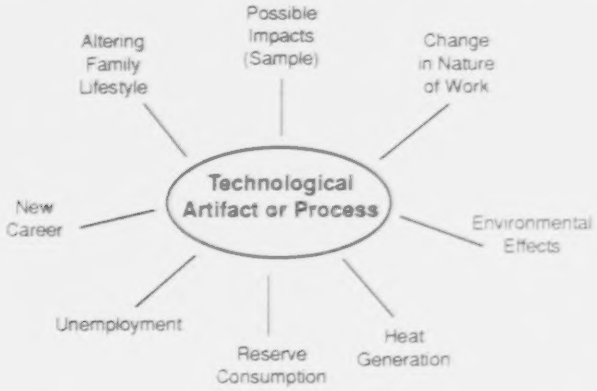
Activity #1: Defining the Task - Plan of Procedure

1. Define the assessment task using its scope as the basic framework for analysis. The scope of the study is defined as the domain of the problem, the type of system involved, and the direct or indirect impacts to be investigated. Some examples include:
   A. Dealing with major problems and important issues such as recycling, solid waste management, etc.
   B. Instituting a range of inquiry about recycling or solid waste management systems.
   C. Developing ground rules on recycling or solid waste management systems.

2. Describe the relevant technologies for each of the seven stages in the system. These should be organized in a framework which is compatible with the system description. They should also be stated in terms which permit the design of specific action options whose impacts can be estimated. The descriptions will also contain judgments concerning the functional characteristics and social acceptability of the technologies and sets of other technologies, using both qualitative and quantitative data.

3. Describe the specific system, such as: recycling or solid waste management. This is made up of three major sub-tasks:
   A. Define subsystems.
   B. Determine anticipated use of each subsystem.
   C. Do a preliminary impact analysis.

4. Identify impact areas, i.e., by ascertaining those societal characteristics that will be most influenced by the application of the assessed technology.

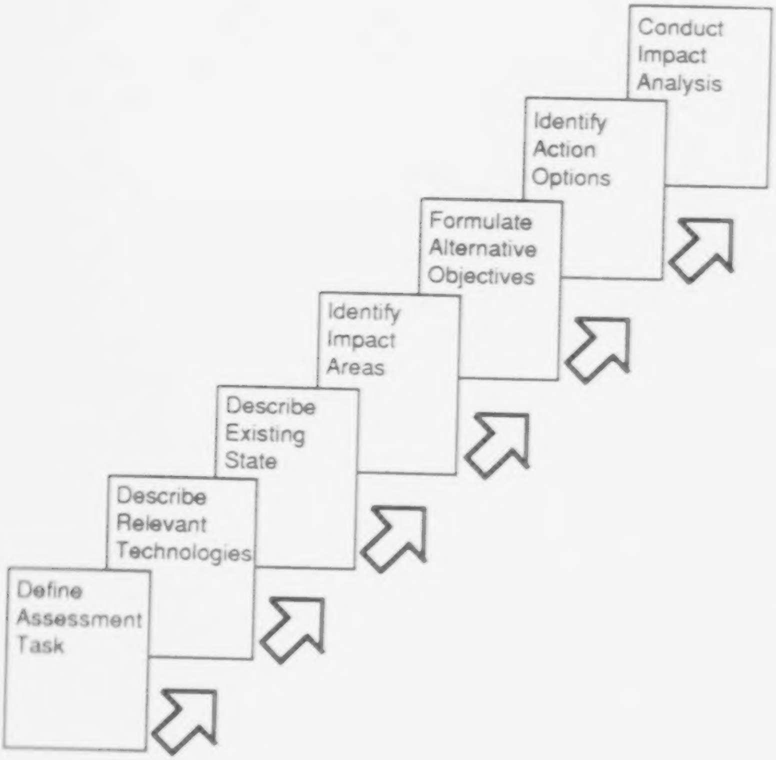

Possible Impacts (Sample)
Altering Family Lifestyle
Change in Nature of Work
Technological Artifact or Process
New Career
Environmental Effects
Unemployment
Reserve Consumption
Heat Generation

5. Formulate alternative objectives from three to five sets which will serve as the functional criteria for identifying specific action options, and which will also include impacts of concern to the public.

6. Identify possible action options. This step involves designing a single option for each of the three to five sets of objectives identified above. The designed action options should satisfy their design criteria as nearly as possible.

7. Conduct an impact analysis. In this final step of the assessment task, estimates of every possible consequence of each action option are developed. The impacts of each action option on the existing system should be put in tabular form for transmission to the local officials. The following should be included for each impact factor and each option:

   A. Type of estimate - quantitative, qualitative or judgmental.
   B. Timing of impact.
   C. Average value and distribution of impact.
   D. Reliability of estimate.
   E. Comparison with standard (fixed) measure.


Define Assessment Task
Describe Relevant Technologies
Describe Existing State
Identify Impact Areas
Formulate Alternative Objectives
Identify Action Options
Conduct Impact Analysis

TAM #4: Technology Assessment Process

Activity #2: Recycling Project - Plan of Procedure

1. Pick a locally viable recycling project, such as paper, glass, oil, anti-freeze, etc. However, if you have not decided on what to recycle, start with step #2.

2. Assemble pertinent information.
   - A. Conduct a local search for information on the material to recycle (e.g., in the local library).
   - B. Analyze the information you obtained regarding the material to recycle.
   - C. Combine the appropriate information resulting from your search and analyze with respect to the material to recycle.
   - D. Finalize your decision on the material to recycle.

3. Collect scrap or other materials for recycling from industry, government, farms, auto-wrecking, households, etc.

4. Sort out the materials according to their group and make.

5. Process the materials by:
   - A. Treatment, such as melting, etc.
   - B. Conversion, such as casting, etc.

6. Package these materials for export to the consumer by:
   - A. Bundling them.
   - B. Briquetting them.
   - C. Baling them, etc.

7. Make arrangement or preparation of the materials for delivery to the consumer.

TAM #4 - Summary

1. **Review & Summary Activities**

   The use of technology assessment as a rational method for evaluating tools and methods for prospective uses of technology cannot entirely eradicate negative side effects, but can ensure that a given technology falls within an acceptable level of risk.

   This TAM taught you how to evaluate processes in order to control the development of technology, so that serious side effects can be avoided.

2. **Review Questions -- Test yourself!**

   A. Discuss the need and process used for recycling aluminum cans.

   B. Discuss recycling of other materials.

   C. What are the concepts and principles developed in this TAM?

TAM #7 - Post-assessment

Instructions:

1. Complete the self-check on technology assessment steps and the recycling of can scrap process.
2. Have the instructor complete the evaluation and discuss discrepancies between the two assessments.
3. Complete the post-test for TAM #4.
4. If your results demonstrate mastery, go on to the next TAM or activity assigned by your instructor. If less than completely successful, see your instructor and ask what to do to raise your level of mastery.

Course: Introduction to Energy & Power Technology

Technology Activity Module #5

Energy Conversions

by: Rodney L. Custer

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ALKALINE
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TAM #5: Energy Conversions

Instructor Component

Activity Objective: The purpose of this activity is to enhance student awareness of the conversion process between various energy sources and outputs. This awareness extends to issues such as conversion efficiency, resource availability, and conservation.

Activity Competencies: By completing this TAM, the student will be able to:

1. Describe the characteristics of major energy sources: chemical, mechanical/kinetic, radiant, electrical, thermal, nuclear.
2. Explain the energy conversion process, and the necessary apparatus, between any two energy sources.
3. Secure and evaluate feedback to assess the effectiveness of an energy conversion method.
4. Build experimental/prototype energy conversion demonstrators and measure their effectiveness.
5. Use laboratory equipment to measure energy conversion variables such as fuel efficiency, heat loss and the like.
6. Define common terms related to the study and use of energy.
7. Define efficiency in energy conversion terms.
8. Identify the status, availability, significance, economic and environment advantages and disadvantages of various alternative energy-systems, e.g., solar, wind. . . , in your community/region.
9. Recognize and respond to the need for energy conservation (electrical, water, fossil fuels) in residential, commercial, industrial, and transportation applications.
10. Differentiate between, and sketch the operation of, internal and external combustion engines.

Module Instructions

Introduction:

This module is designed to introduce students to some principles related to energy conversion. Throughout the TAM, they will be encouraged to expand their awareness of the variety of energy sources that are available for conversion. Students will also experiment with some traditional and some non-traditional forms of conversion. The three activities which are built into the module are designed to be used independently of one another. It is recommended, however, that all three be done to provide "the big picture" of energy conversion.

Safety Considerations:

The recommended safety considerations for this TAM are those practiced in general Industrial Technology Education laboratories. Experimentation in activities #1 and #2 will require some special precautions depending on what students choose to do. The use of a heat source in Activity #2 will require special instruction related to the equipment use and the use of flame around combustible materials. Energy conversion experimentation in Activity #1 should be cleared by the instructor prior to testing by students.

Needed Materials:

1. **Supplies Required**
   - A. Demonstrating/Illustration Energy Conversion
     1. Chart pad for brainstorming activity
     2. Markers for chart pad
     3. Art materials for constructing a display
     4. Small propane torch (optional)
     5. Thermocouple (optional)
     6. VOM (optional)
   - B. External Combustion - The Stirling Engine
     1. Selection of construction grade wood materials
     2. 12" length of 1/4" mild steel rod
     3. Small pieces of flat 1/8" metal strip material
     4. Bolt and screw assortment
     5. 2 - screw-eye hooks
     6. 2 - 3/16" x 36" dowel rods
     7. 2 - 1 lb. coffee cans
     8. 2 - empty soda cans
     9. 8" dia. V-belt pulley
     10. Metal shaft material for flywheel weighting
     11. 2 - 3/4" I.D. copper elbows
     12. 15" - 3/4" I.D. copper tubing
     13. Epoxy glue (slow cure type)
     14. Light wire mesh
   - C. Energy Futures
     1. Display materials
     2. Prototype development materials as required
2. **Equipment/Machines/Tools**
   - A. Demonstrating/Illustration Energy Conversion
     1. Materials and processing laboratory equipment and tools
     2. Word-processing equipment (or typewriter)
     3. Graphic arts equipment as needed for display development
   - B. External Combustion - The Stirling Engine
     1. Materials and processing laboratory equipment and tools
     2. Propane or oxyacetylene torch
     3. Thermometer

C. Energy Futures
   1. Materials and processing laboratory equipment and tools.
   2. Graphic arts equipment as needed for display development.

3. Handouts

A. Student component of TAM #5

B. Background information sheet on the Stirling engine and external combustion

4. Instructional Resources

A. Books and Articles

1. Buban, Peter, Schmitt, Marshall L., & Carter, Charles G. (1987). Understanding electricity and electronics technology. New York: McGraw-Hill.
2. Goetsch, David L. & Nelson, John A. (1987). Technology and you. Albany, NY: Delmar Publishers.
3. Glock, John, McQueen, Ron & Towler, Alan. (1989). Energy systems - laboratory activities. Austin, TX: University of Texas at Austin Extension Instruction and Materials Center, Division of Continuing Education.
4. Jones J. B., & Hawkins, G. A. (1986). Other externally reversible cycles. Engineering thermodynamics: An introductory textbook. New York: John Wiley & Sons.
5. Karwatka, Dennis & Kozak, Michael R. (1987). Energy, power, and transportation. Orlando, FL: Harcourt Brace Jovanovish, Inc.
6. Smith, Howard B. (1985). Exploring energy: Sources, applications, alternatives. South Holland, IL: Goodheart-Willcox Co.
7. Walker, Jearl. (1990). The amateur scientist. Scientific American, 262 (1), 140-144.
8. Walker, John R. (1981). Exploring power technology. South Holland, IL: Goodheart-Willcox Co.
9. Walker, Graham. (1973). The stirling engine. The Scientific American, 229 (2), 80-87.
10. Walker, Graham. (1980). Stirling engines. London, England: Oxford University Press.
11. West, Colin D. (1983). Liquid piston stirling engines. Van Nostrand Reinhold Company.
12. West, Colin D. (1986). Principles and applications of stirling engines. Van Nostrand Reinhold Company.

Management/Logistics:

1. Related TAMS

Two TAMS are recommended as supplemental material in helping students work through the activities presented in this TAM. These are:

- TAM #3 - Design and Using Experiments (E&P Guide)
- TAM #2 - Problem Solving (M&P Guide)

2. **Evaluation/Grading**

   Student assessment for this TAM will need to be designed to accommodate both individual and group evaluation. The most direct individual evaluation will be performance on the pre- and post-tests. Additional individual evaluation will need to be based on the quality of individual participation in group activities.

   Group activities can be evaluated on the basis of:

   A. Quality and creativity evidenced in the creation of suggested displays.
   B. The crafted quality of the Stirling Engine.
   C. The amount of initiative that groups take in experimenting with the efficiency experiments (Activity #1), with the engine variables (Activity #2), and inventiveness (Activity #3).

3. **Suggested Schedule/Time**

   The suggested time period for this TAM is approximately three weeks. The activities are structured in such a manner that they need not be done consecutively. Selected portions of each activity could be assigned to students as enrichment for other aspects of the Energy and Power curriculum.

Key Instructional Suggestions:

1. **Safety**

   The experimental activities in this TAM require that you stress safety precautions that go beyond those normally used in general Industrial Technology Education laboratory work. Students should be monitored with special care to assure that they are not about to experiment in some dangerous ways. It would be prudent to require instructor checkpoints at two or more points during the experimentation process, one in the idea development stage, and one just prior to performing the actual process.

2. **Motivation**

   The initial stages of this TAM will require some special motivation. Students may resist the process of generating ideas and engaging in inventiveness. Often this is because they feel overwhelmed and inadequate to the task. It will be important for instructors to have considered options and ideas in order to be able to maintain enthusiasm for the tasks. If possible, it will be beneficial to build the activities into competitive events. Enthusiasm can be generated by recognition received from having the results of student work placed downtown in public view, for example.

3. **Prerequisite Information**

   Students will be able to benefit more from this TAM if it is preceded with some energy fundamentals information and some basic physics concepts. While this background would be helpful prior to doing the TAM, the activities contained in the TAM can also serve as a useful mechanism for presenting fundamental energy and physics concepts.

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Please note the instructional sheet located at the end of the instructor component of this TAM. This sheet provides additional background information on the principles behind the operation of the Stirling engine. It is recommended that the discussion and presentation of external combustion theory be done **following** construction and initial operation of the engine.

4. Demonstrations

Instructors should be prepared to be highly involved in the initial stages of brainstorming and idea generating throughout all three activities. If a model Stirling engine has already been constructed, demonstrate its operation as a start-up activity. Depending on the direction students go with their experiments, instructors should be alert to the need for other demonstrations.

5. Reinforcement

This TAM provides excellent potential for reinforcing basic concepts from physics, biology, and chemistry. The design activities also reinforce courses in art, design, and product/sales promotion.

6. Attitudes

This TAM can stimulate creative interests and abilities in students. It will be important to provide guidance and encouragement. Students may feel as though they lack the background to contribute. Part of the challenge of teaching this type of activity is to help students realize how much background information they have and take for granted.

7. Remediation/Enrichment

Remediation: It may be necessary to review some of the procedures for using certain equipment in some laboratories. Certain activities in the TAM may require that students use equipment or knowledge that they have not used recently. In some cases they may not have had prior instruction (for example, the effect of heat on gas volume or on brazing with the oxyacetylene torch).

Enrichment: Each of the activities provide opportunities for enrichment. For example, in Activity #2, students could experiment with the effects of adjusting many different variables in the Stirling engine. In Activity #3, students could be encouraged to actually develop a prototype invention.

8. Summary & Review

The following are key points which the instructor should summarize:

A. There are numerous conversions for changing energy from one form to another.

B. Some forms of conversions occur in nature, e.g., photosynthesis in plant life. Other require intervention from technology, e.g., hydroelectric power generation.

C. Principles of thermodynamics (outlined in Handout #1) should be reviewed in order to help students understand the operation of the Stirling engine.

D. Review concepts and procedures involved in estimating and calculating the efficiency of energy conversion.

E. Review the factors which are likely to determine the kinds of energy and energy conversion in the future.

9. **Review Questions & Answers *(Answers are in italics)***

A. External combustion involves the burning of fuel ____________ of the cylinder. (*outside*)

B. A general term referring to changing of one form of energy to another by plants or microorganisms is called ________________________. (*bioconversion*)

C. The ratio between the amount of energy put into a power system and the energy output from the system is called ____________________. (*efficiency*)

D. The term ________________________ refers to the ability to do work. (*energy*)

E. A steam engine is an example of what type of combustion engine (internal or external)? (*external*)

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #5: Energy Conversions - Pre-test

Instructions: Circle the statement which **best** completes the sentence.

1. Energy is:
   - A. a by-product of sunlight and decayed matter.
   - B. the ability to do work.
   - C. something that must be converted by technology.
   - D. a substance through which power is transmitted.

2. A motor is a device which:
   - A. converts potential energy into electrical energy.
   - B. requires no energy conversion mechanisms.
   - C. operates on a principle called photoconductivity.
   - D. converts electrical energy into mechanical energy.

3. The term efficiency, when used in connection with energy conversion processes refers to:
   - A. changes which generate very little friction.
   - B. a ratio of energy into a system to energy out of a system.
   - C. changes in energy which can be done at a low cost.
   - D. changes in energy which require little time and effort.

4. External and internal combustion engines:
   - A. are distinguished by where the combustion occurs.
   - B. both involve the burning of fossil fuels.
   - C. are essentially the same thing.
   - D. may both be used in front wheel drive cars only.

5. Scientists estimate that our supply of fossil fuels will last approximately ________ more years.
   - A. 10
   - B. 30
   - C. 50
   - D. 75

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #5: Energy Conversions - Post-test

Instructions: Answer each question in the space provided.

1. Explain the difference between the following types of energy conversion.
   - Bioconversion
   - External combustion
   - Internal combustion
   - Thermomagnetic conversion
   - Hydroelectric conversion

2. Name the energy source and energy output for the following sample conversions.

Energy Source	Example Conversion	Energy Output
	Bird Flying	
	Photo Voltaic Cell	
	Automobile Generator	
	Flashlight Battery	
	Microwave Oven	
	Light Bulb	
	Bicycle	

3. Briefly explain how the Stirling engine works.

TAM #5: Energy Conversions - Test Keys

TAM #5 - Pre-test Answers

1. B 2. D 3. B 4. C 5. D

TAM #5 - Post-test Answers

1. **Bioconversion** is a general term referring to energy changes which take place in plants, animals, and microorganisms.

   External Combustion refers to engines in which combustion occurs outside of the cylinder.

   Internal Combustion refers to engines in which combustion occurs inside of the cylinder.

   Thermomagnetic Conversion refers to devices which convert a magnetic field into electric current.

   Hydroelectric Conversion refers to processes or devices which convert mechanical energy from water movement into electrical current.

2. Name the energy source and energy output for the following sample conversions.

Energy Source	Example Conversion	Energy Output
Chemical	Bird Flying	Mechanical
Light	Photo Voltaic Cell	Electrical
Mechanical	Automobile Generator	Electrical
Chemical	Flashlight Battery	Electrical
Electrical	Microwave Oven	Heat
Electrical	Light Bulb	Light/Heat
Chemical	Bicycle	Mechanical

3. Briefly explain how the Stirling engine works.

   The engine works because of changes in air volume and air pressure within the cylinder. Both changes are the result of thermal expansion and contraction brought about by the hot and cold water tanks. They are also the result of the mechanical compression of air by the force generated by the movement of the weighted flywheel.

TAM #5 - Handout 1

Instructional Sheet

The Stirling Engine - Operational Principles

The Stirling engine is a very simple machine. In its "home-made" form it appears to be even more simple. Its operation is based on some basic principles of thermodynamics. Even though the principles are simple, you will want to spend some time thinking about what is happening inside of the air cylinder at various stages of the engine cycle. It will be helpful in the process to refer to Figure #4, p. 16 in the student component. You will also find that it will help you visualize the process if you will turn the engine by hand through each of the stages as you review the chart.

Let's walk through the stages of the engine's operation. We'll begin at stage (A).

1. At stage (A), the weight and momentum of the flywheel has forced both soda cans to their lowest extreme position. The effect on the air inside of the cylinder (copper air tube) is that it is compressed. Another way of thinking of this is that the volume has been reduced to its minimum level.

2. During stages (B-E), hot water in the hot water tank is rapidly expanding the air in the cylinder. Not only is the air expanding in volume, the air pressure is also rising. The net effect of the increased volume and pressure is that both soda cans are forced to rise. This pressure is sufficient to overcome the inertia being exerted by the weight of the flywheel on the system.

3. At position (E), the expansion peaks out. At this point the weight of the flywheel takes over. The soda cans are forced downward into the water tanks. This causes several things to happen. It would seem that the air pressure would increase because the air is being packed into a smaller volume. That would be true except for one important factor. At the same time that the air is being compressed, the water in the cold water tank is reducing the total pressure and volume of the air. In effect, this reduction assists the weight of the flywheel in driving the soda cans downward.

4. The downward movement continues through positions (F-A), at which point the cans have once again reached their extreme bottom positions. At this point the cycle is repeated.

5. In order to better understand the principles of operation it is recommended that students experiment with some of the engine's parameters. Suggested changes include: changing the temperature of the water in the tanks (the hot water tank may be brought to the boiling point); changing the length of the stroke (adjustments made at the end of the crank); adding or removing weight from the flywheel; changing the angle of the crankshaft ends; adding a regenerator material to the air tube (to increase the efficiency of the air cooling during the movement from position (F) to position (A)).

TAM #5: Energy Conversions

Student Component

Introduction:

We almost never think about it, but it's happening around us and even inside of us all the time. Energy is changing forms. Think about it. Your body is changing food from organic matter into chemical substances that feed your muscles which in turn allow you to exert mechanical energy on your environment. Your car is able to change gasoline from a liquid chemical to mechanical energy. Water flowing through dams generates electricity. Electrically generated heat toasts your bread in the morning and heats your bed at night. Energy conversion is occurring all the time.

Competencies:

Following the completion of this TAM, you will be able to:

1. Describe the characteristics of major energy sources: chemical, mechanical/kinetic, radiant, electrical, thermal, nuclear.
2. Explain the energy conversion process, and the necessary apparatus, between any two energy sources.
3. Secure and evaluate feedback to assess the effectiveness of an energy conversion method.
4. Build experimental/prototype energy conversion demonstrators and measure their effectiveness.
5. Use laboratory equipment to measure energy conversion variables such as fuel efficiency, heat loss and the like.
6. Define common terms related to the study and use of energy.
7. Define efficiency in energy conversion terms.
8. Identify the status, availability, significance, economic and environment advantages and disadvantages of various alternative energy systems, e.g., solar, wind. . . , in your community/region.
9. Recognize and respond to the need for energy conservation (electrical, water, fossil fuels) in residential, commercial, industrial, and transportation applications.
10. Differentiate between, and sketch the operation of, internal and external combustion engines.

Module Overview:

This module is designed to make you aware of all kinds of energy conversions that are going on all the time in your environment. Some of these happen naturally in nature. Many others are created by technology in order to provide power for some system or to change an energy source into a form in which it can be more easily or economically used.

In this module you're going to have the chance to do some experimenting with some different types of energy conversions. In addition, you'll be able to make an unusual kind of engine, one that runs on external, rather than the typical internal combustion (like your car engine).

Activity Sequence:

1. Participate in your instructor's start-up activities and presentation for this TAM. Some reading assignments and safety considerations will be provided.
2. Do Activity #1. You will notice that this activity actually contains several parts and options. While you may certainly use the efficiency experiment which is outlined in the activity, you are encouraged to develop one of your own. Consult with your instructor about the idea to make sure it is both safe and feasible. Also, note that the activity involves a considerable amount of group work. You can break down tasks into duties for individual group members to do. The activity has possibilities for developing into a good competitive event for the class.
3. Construct the Stirling engine as outlined in Activity #2. This can be done individually, in small groups, as a class, or as a mass production activity. You will want to pay particular attention to the instructor's classroom presentations regarding how the engine works. A handout has been provided to aid your understanding.
4. Operate your Stirling engine as constructed. Experiment with a variety of heat ranges for the hot tank. Be sure to record the information. Next, experiment with the variables suggested at the end of Activity #2. Pay particular attention to the factors that increase the power output and efficiency. Think through why the changes had the effect they did.
5. Do Activity #3. In this activity you will be encouraged to contact some local persons as well as some well known national and even international figures. Don't assume that these people would never respond to a high school student. Make your letter read well and look sharp. Who knows, they may surprise you. After all, this is their interest, too.
6. As a part of Activity #3, attempt to be as inventive and creative as you can. Don't underestimate yourself. This is a chance to suggest some wild ideas. After all, that's how many inventions got started. Imagine what the neighbors had to say when Franklin was flying a kite in a thunderstorm.

Key Information:

1. **Class Presentations**

   Your instructor will:

   - present some material that will help you better understand just how broad the subject of energy conversion is.
   - assist you in understanding the basic principles of something called "thermodynamics." The principles of thermodynamics are involved in making the Stirling engine run. At first it may sound a little complicated. After you understand a few of these basic principles, it's really not difficult at all.

- assist you in thinking through some potential energy sources and conversions that we're going to need in the future to supply our power.

2. **Demonstrations**
    - How to set up the thermocouple experiment (Activity #1).
    - How to braze materials together (Activity #2).
    - How to mix and apply slow curing epoxy glue. (Activity #2).
    - The operation of the Stirling engine (Activity #2).
    - Other demonstrations as necessary to prepare a display or to conduct the experiments or operations (Activities #1, #2, and #3).

3. **Safety**

    You should follow the safety procedures which have been applied throughout the entire Industrial Technology Education course. As you conduct experiments in this TAM, always keep safety in mind. Before you start on something which is unfamiliar to you, check with the teacher to make certain that the tools and equipment are safe for you.

4. **Personal Activity**

    Before beginning work on these activities, you will need to complete the reading which has been assigned by your instructor. The background information will help you have more fun and learn more during the course of doing the activities. A handout has been developed for Activity #2. This is designed to help you understand how the Stirling engine works. The instructor will go over this with you as well.

Glossary:

1. **Accumulator** - Another name for a storage battery. Electrical energy is stored as chemical energy.
2. **Bioconversion** - A general term meaning the changing of one form of energy to another by plants or microorganisms. An example is a plant changing solar energy into chemical energy.
3. **Changeable Energy Source** - Energy source which is not always available. For example, wind or solar which varies with changes in the weather.
4. **Chemical Energy** - Energy locked away and stored in elements such as growing plants, coal, oil, or other compounds.
5. **Direct Energy Conversion** - This refers to the conversion of one form of energy into another for the purposes of doing work. An example includes the conversion of chemical energy from an automobile battery into electrical power for the ignition system.
6. **Efficiency** - The ratio between the amount of energy put into a power system and the energy output.
7. **Energy** - The ability to do work.
8. **Energy Transfer Medium** - A substance through which energy can be transmitted.
9. **Entropy** - A measure of the unavailable energy in a closed thermodynamic system.
10. **External Combustion Engine** - An engine in which the fuel is burned outside the cylinders.
11. **Fuel Cell** - An energy conversion device which combines fuel and oxygen to produce electrical energy without combustion.
12. **Generator** - A device that converts mechanical or heat energy into electrical energy.
13. **Geothermal Energy** - A source of energy from deep inside the earth's core.
14. **Heat Exchanger** - A device that allows heat from one substance to flow to another without the substances coming in contact.
15. **Internal Combustion Engine** - An engine in which the burning of fuel occurs inside of the engine.
16. **Kinetic Energy** - The ability of moving objects or matter to do work.
17. **Mechanical Energy** - Kinetic energy or energy of motion.
18. **Nuclear Energy** - Energy which is released by splitting an atom of matter.
19. **Photosynthesis** - A chemical process whereby plants are able to absorb and store solar energy.
20. **Photovoltaic Cell** - A device that produces direct current from sunlight (a solar cell).
21. **Potential Energy** - Energy at rest or in storage which is not working but is capable of doing work.
22. **Renewable Energy Sources** - Energy sources that come from sources which can be replaced.
23. **Stirling Engine** - An external combustion engine in which air or hydrogen is first heated and then cooled to drive the piston up and down.
24. **Thermoelectric Converter** - A device which generates electricity directly from heat applied to the junction of two unlike metals. A common example is a thermocouple.
25. **Thermomagnetic Conversion** - Devices which use heat to make changes in the magnetic field of a magnet which result in the creating of an electric current.

Needed Materials:

1. **Supplies Required**
   - A. Demonstrating/Illustration Energy Conversion
     1. Chart pad for brainstorming activity
     2. Markers for chart pad
     3. Art materials for constructing a display
     4. Small propane torch (optional)
     5. Thermocouple (optional)
     6. VOM
     7. Ammeter
   - B. External Combustion - The Stirling Engine
     1. Selection of construction grade wood materials
     2. 12" length of 1/4" mild steel rod
     3. Small pieces of flat 1/8" metal strip material
     4. Bolt and screw assortment
     5. 2 - screw-eye hooks
     6. 2 - 3/16" x 36" dowel rods
     7. 2 - 1 lb coffee cans
     8. 2 - empty soda cans
     9. 8" dia. V-belt pulley
     10. Metal shaft material for flywheel weighting
     11. 2 - 3/4" I.D. copper elbows
     12. 15" - 3/4" I.D. copper tubing
     13. Epoxy glue (slow cure type)
     14. Light wire mesh
   - C. Energy Futures
     1. Display materials
     2. Prototype development materials as required

2. **Equipment/Machines/Tools**
   - A. Demonstrating/Illustration Energy Conversion
     1. Materials and processing laboratory equipment and tools
     2. Word-processing equipment (or typewriter)
     3. Graphic arts equipment as needed for display development
   - B. External Combustion - The Stirling Engine
     1. Materials and processing laboratory equipment and tools
     2. Propane or oxyacetylene torch
     3. Thermometer
   - C. Energy Futures
     1. Materials and processing laboratory equipment and tools
     2. Graphic arts equipment as needed for display development

3. **Handouts**
   - A. Student component of TAM #5
   - B. Background information sheet on the Stirling engine and external combustion

TAM #5: Energy Conversions

Activity #1: Demonstrating/Illustrating Energy Conversion - Plan of Procedure

1. Working in small groups, brainstorm as many different types of energy conversions as you can. (This activity could be done competitively, with several small groups attempting to identify the largest number of possible conversions).

2. Think of real life examples for each of the conversions that you have identified.

3. Develop a chart which shows all of the information that you have identified. An example chart could appear as follows:

Energy Source	Example Conversion	Energy Output
Electrical	Light Bulb	Light
Light	Photo Voltaic Cell	Electrical
Mechanical	Automobile Generator	Electrical
Chemical	Battery	Electrical
Electrical	Toaster	Heat
Fossil Fuel	Wood Burning Stove	Heat
Human	Bicycle	Mechanical

4. Using the information developed in the table, create a display that illustrates the conversions in some graphic form. Do this as a group. Be creative. This could be in the form of a collage, a flow diagram, or any other format that your group would like to use. One possibility is shown on the following page (Figure #1).

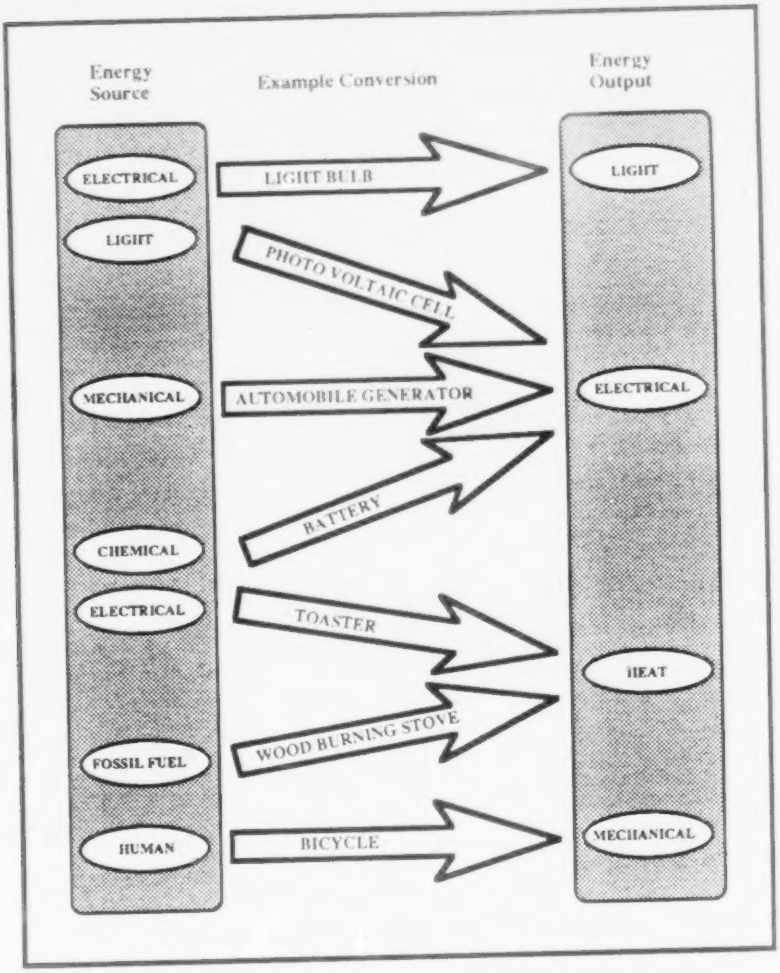

Energy Source
Example Conversion
Energy Output
ELECTRICAL
LIGHT BULB
LIGHT
LIGHT
PHOTO VOLTAIC CELL
MECHANICAL
AUTOMOBILE GENERATOR
ELECTRICAL
BATTERY
CHEMICAL
ELECTRICAL
TOASTER
HEAT
WOOD BURNING STOVE
FOSSIL FUEL
HUMAN
BICYCLE
MECHANICAL

Figure #1 - Energy Conversion Sample Display

5. Using an expanded energy conversion form (Figure #2), estimate the efficiency for each type of conversion. Use the following efficiency coding system:

   H - Highly Efficient Energy Conversion
   M - Moderately Efficient Energy Conversion
   L - Inefficient Energy Conversion

   Do this individually first. After each student has estimated the efficiency for each conversion, present them to the group. Working as a group, come to agreement on the efficiency for each. Agreement should be based on convincing arguments and reasons.

Energy Source	Example Conversion	Energy Output	Estimated Efficiency (H, M, L)
Electrical	Light Bulb	Light	
Light	Photo Voltaic Cell	Electrical	
Mechanical	Automobile Generator	Electrical	
Chemical	Battery	Electrical	
Electrical	Toaster	Heat	
Fossil Fuel	Wood Burning Stove	Heat	
Human	Bicycle	Mechanical	

Figure #2 - Estimated Efficiencies

6. Next, select one conversion with which you can actually do efficiency testing. (Note: The following procedure is designed to be an illustration of only one possible conversion that could be tested for efficiency. While you may wish to do this particular one, you are encouraged to develop a means for testing another one of the conversion possibilities.)
7. Test the efficiency of a thermocouple device as a converter from heat to electricity. For the experiment, you will need a small propane torch, a thermocouple, an ammeter and a VOM. The torch will serve as the energy source (heat). The VOM will indicate the amount of energy output (electricity). The thermocouple device is the device that performs the energy conversion.
8. Weigh and record the weight of the propane bottle.
9. Apply heat to the thermocouple and observe the change in the electrical output. Record the change. At this point reweigh and record the weight of the propane bottle (Figure #3).

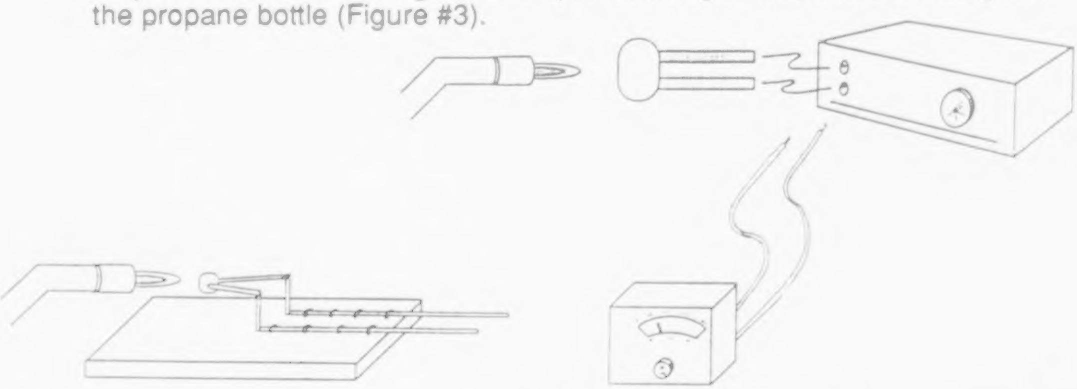


Figure #3 - Thermocouple Experiment Configuration

10. Reapply the heat to the thermocouple such that an increased level of electrical output is achieved. Again record the changes in terms of time, propane bottle weight, and electrical output level. Record your results in the following chart.

Bottle Weight	Time	Electrical Output	Cost

11. On the basis of your experiment, indicate whether your previous efficiency estimate for heat to electrical conversion was justified. You will want to think carefully about how you choose to define efficiency. It can be in terms of cost or time. Also notice that efficiency levels can change for different levels of output. For example, a thermocouple may be a very efficient converter up to a certain point. Beyond that point, it may take a large amount of gas and time to create even small amounts of additional energy. So, beyond a certain point, the efficiency of certain conversions may change drastically.

12. Pool the information from the experiments done by the other groups or individuals in the class. Incorporate this efficiency information into the estimates made prior to the experiments. Observe the degree to which you were on or off target with your estimates.

13. Incorporate the efficiency information and experimental processes into your display.

14. Arrange to display your completed display in the school's display case, in a display window at a local utility, or some other location of your choice.

Activity #2: External Combustion - The Stirling Engine - Plan of Procedure

The plan of procedure for this activity has been divided into two parts. Part A consists of the construction of a Stirling engine. Part B will consist of some experiments which will show how various changes affect the performance of the engine.

Part A: Construction of the Stirling Engine

1. Construct the engine support framework (see Fig. #5). The easiest and most economical construction material is wood. Dimensions for this structure are variable. However, it should be constructed to allow for:

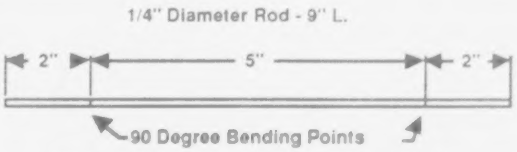
    - 36" Long Connecting Rods
    - An 8" Dia. Flywheel
    - The height of 1 Pound Coffee/Soda Can Configurations
    - Air Exchange tube and Support

    The structure will consist of the following parts:

    - 1 - 2" x 3" stand
    - 2 - Crankshaft and connecting rod supports
    - 1 - Connecting rod support spacer
    - 1 - Base and 3 stabilizer supports
    - 2 - Air tube supports

    The overall height of the engine will be approximately 55 inches.

2. Fashion bearings for the crankshaft to frame connection. This can be done with a notched strip of sheet metal (as pictured in Fig. #5), or by a pillow block or roller bearing configuration. The primary design specification is that movement be as unrestricted as possible.
3. The flywheel configuration can be constructed from a salvaged V-belt pulley. It should be approximately 8" in dia. Weights can then be taped to the grooves to provide mass for flywheel momentum. Make a wooden plug to insert through the flywheel opening. The length of the plug should be such that it restricts flywheel side to side movement between the bearing supports.
4. Make a crankshaft from a 1/4" diameter rod. (Figure #4).



NOTE: The two cranks must be offset from each other by 90 degrees (see Figure #5).

Figure #4

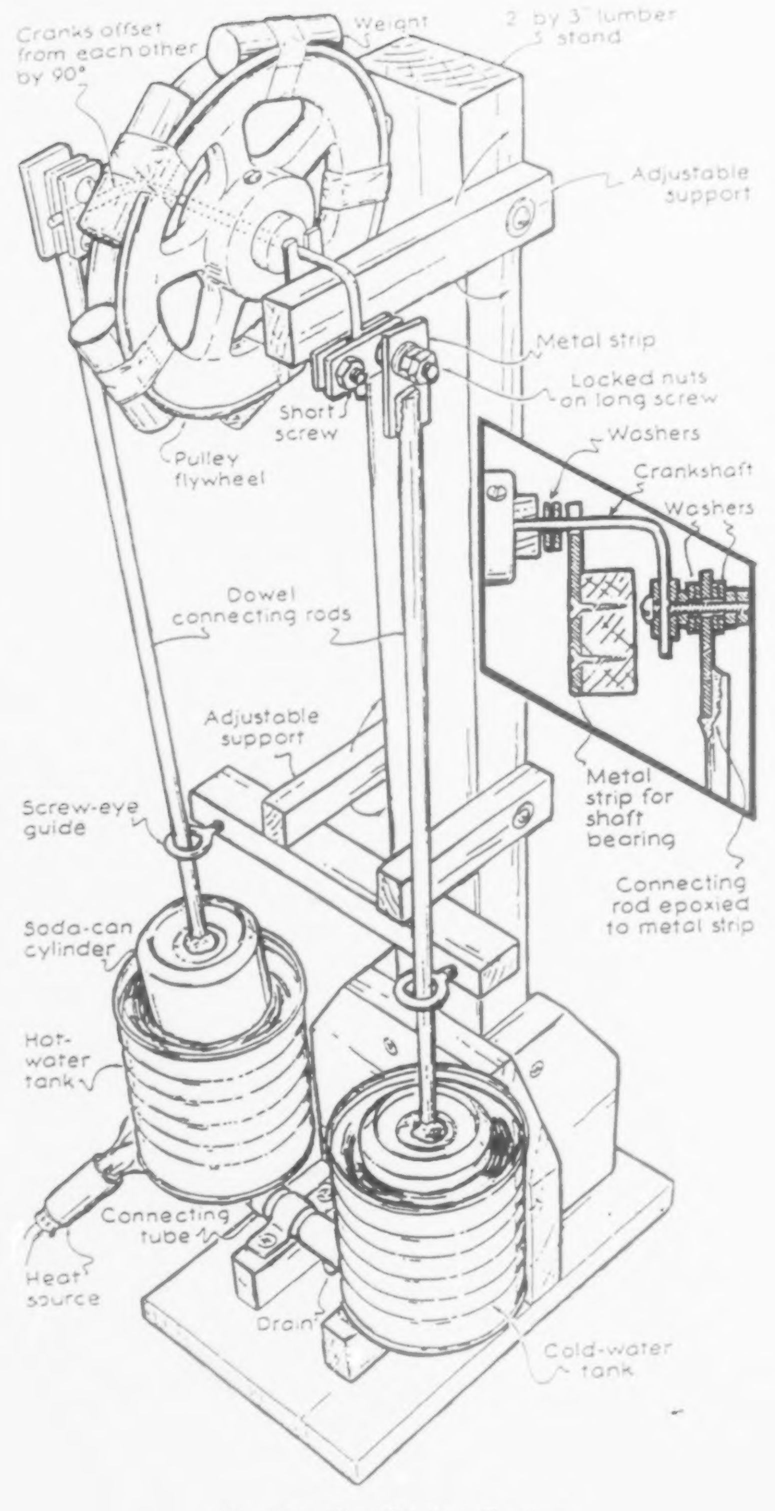

Cranks offset from each other by 90°
Weight
2" by 3" lumber stand
Adjustable support
Metal strip
Locked nuts on long screw
Short screw
Pulley flywheel
Washers
Crankshaft
Washers
Dowel connecting rods
Adjustable support
Metal strip for shaft bearing
Connecting rod epoxied to metal strip
Screw-eye guide
Soda-can cylinder
Hot-water tank
Connecting tube
Heat source
Drain
Cold-water tank

Fig. #5 - The Stirling Engine

Artwork used by permission of Scientific American.

5. Cut the tops off two soda cans with a hacksaw. Attach a 36" - 3/16" dowel to the bottom of each can as pictured. This is best done by using a slow curing type of epoxy glue. (NOTE: The glue will need to be able to withstand heat. The fast curing types of epoxy do not hold up as well under those conditions.) At the other end of the dowel fashion and attach a flat metal strap for connection to the crankshaft assembly. This can also be done with epoxy.

6. Construct the crank journal connection as shown in Fig. #6. At this point, test the assembly for freedom of movement.

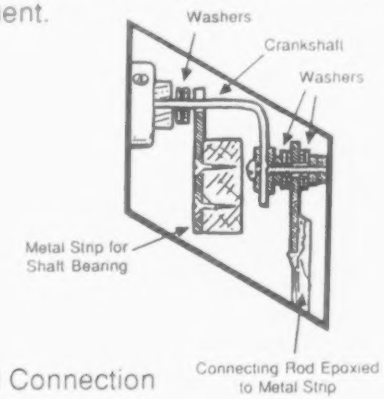

Washers
Crankshaft
Washers
Metal Strip for Shaft Bearing
Connecting Rod Epoxied to Metal Strip

Fig. #6 - Crank Journal Connection

7. Next, construct the air cylinder/heat exchange unit (see Fig. #7). The unit is constructed from two one-pound coffee cans, one for the hot tank and another for the cold tank.

8. The air exchange tube is made from a section of 3/4" I.D. copper tubing. You will need:

- 2 - 5 1/2 " sections
- 2 - 90 degree elbows
- 2 - short sections (long enough to provide spacing between the coffee cans)
- 1 - A drain coupling (this can be done by drilling a small hole fitted with a removable wooden plug)

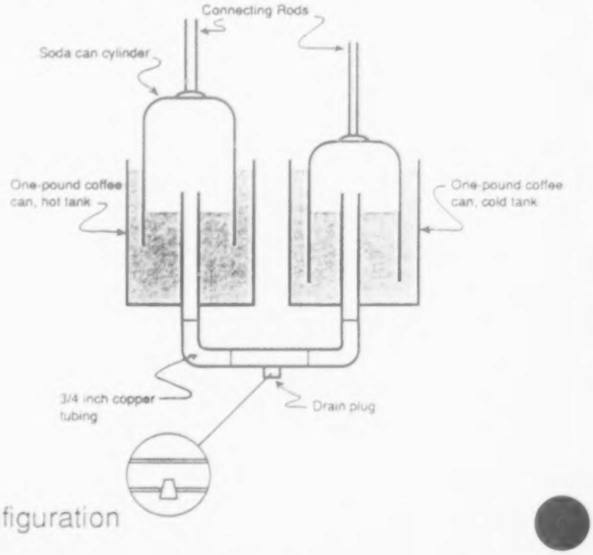

Connecting Rods
Soda can cylinder
One-pound coffee can, hot tank
One-pound coffee can, cold tank
3/4 inch copper tubing
Drain plug

Fig. #7- Air Exchange Configuration

9. Assemble the heat exchange unit by soldering all connections. One joint should be taped (with a vinyl tape) to provide access to the interior of the tubing to allow for the insertion of a regenerator material. (This will be discussed in more detail at a later point in the TAM).

10. Attach the assembled heat exchange unit to the engine support framework as shown in Fig. #5.

11. Adjust the crank journal connection to get a stroke length of 1.5 inches. To do this, adjust both connecting rod pivot points to 3/4" offset from the crankshaft center. Test the engine for freedom of movement.

Part B: Operation of (and Experimentation with) the Stirling Engine

1. Prepare the engine for operation by filling the tanks with water. To do this, the crankshaft must be in the proper orientation. The correct position is when both crank ends are pointed upward at angles of 45 degrees (see stage (d)) in Figure #8.

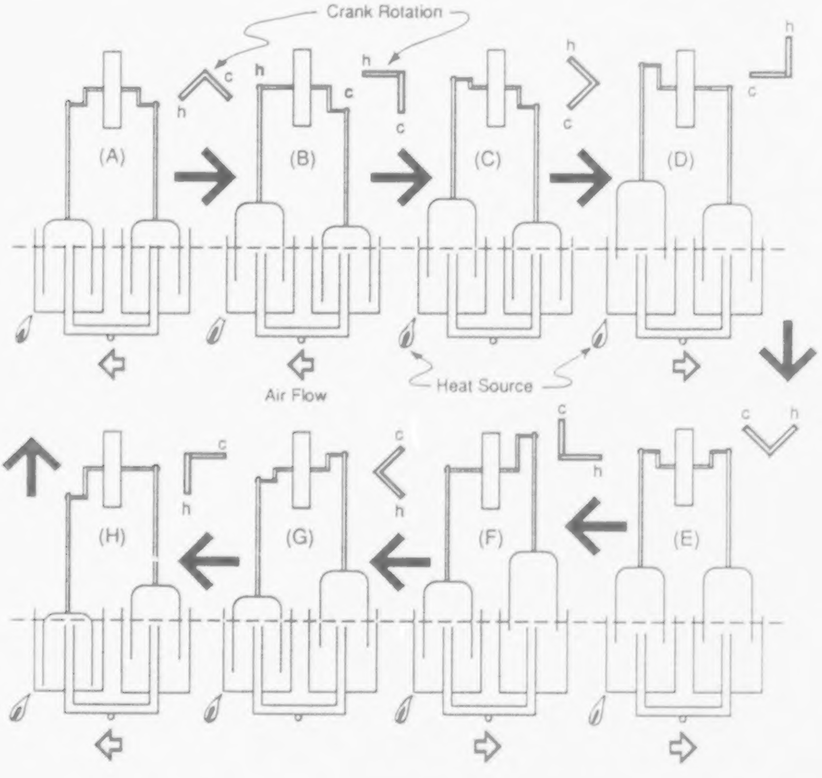


Figure #8 - Crank Position Sequencing Diagrams

2. With the drain open, fill the cold water container until water overflows through the drain hole. Next, fill the hot water tank with heated water until it, too, overflows. At this point, plug the drain hole.

3. Using a thermometer, record the beginning temperature of the water in the hot tank. Heat the hot water tank with a propane torch or a Bunsen burner until the engine begins to turn. Count and record the revolutions per minute. (NOTE: In the event that the engine does not turn properly, check to see if adequate mass has been attached to the flywheel assembly, if the assembly is turning freely, or if the water is sufficiently heated.)

4. Continue to heat and record the water temperatures, keeping track of corresponding changes to the RPM of the engine. Note that the water can continue to be heated up to the boiling point. On the basis of the experiment, answer the following questions.

    A. What causes the engine to move?
    B. What effect does temperature have on RPM?
    C. What purpose does the cold tank serve?
    D. Does the volume of air inside the tubing and soda cans stay the same throughout the cycle? Explain your answer.
    E. Does the air pressure inside the tubing and soda cans stay the same throughout the cycle? Explain your answer.
    F. What purpose does the weighted flywheel serve? What would happen if the weight was removed?

5. Next, perform the experiment using a regenerator material. To do this, disassemble the heat exchange unit at the taped joint. Partially fill the interconnecting tube with wire mesh material. This material should be very loosely packed so air movement will not be restricted.

6. Refill the cans and operate the engine. Repeat the temperature variations, recording the RPM for each temperature. What differences are observed with the addition of the regenerator material? You may wish to experiment with some variety of regenerator materials. On the basis of the experiment, answer the following questions:

    a. What effect did adding the regenerator material have on RPM?
    b. Why did the regenerator material have the effect it did?

7. Experiment with other changes to the engine and observe the results. Possibilities include:

    A. Increasing the stroke length for the connecting rods.
    B. Altering the crankshaft offset angle away from 90 degrees.
    C. Adding or subtracting weight from the flywheel.

On the basis of these changes and experiments answer the following questions:

A. Why does the crank angle matter?
B. What happens if the cold crank leads the hot crank?
C. When the stroke length is altered, the volume of available air is either increased or decreased. What effect did these changes have on the operation of the engine? Why?
D. Why does the engine work?

TAM #5: Energy Conversions

Activity #3: Energy Futures - Plan of Procedure

In activity #1 you identified a large number of possible energy sources and conversions that are in use today. Some, like fossil fuel and mechanical energy, have been extremely popular for a number of years. The supply, however, is running out. The purpose of this activity is to help you find out what the possible sources and conversions of the future are likely to be.

1. As a class, conduct a brainstorming session identifying the persons in your community, state, nation, or other nations that you think would have good ideas about what the energy sources and conversions will be in the future. Possibilities at the local level could include someone from a local power company, a person who is using alternative energy sources such as solar or wood, a science teacher, etc. At the state, national, and international levels, include political figures, scientists and technologists from universities, the persons who wrote your textbook, race car developers, etc. You may also wish to contact the Missouri Department of Natural Resources and Extension Services at the University of Missouri-Columbia.

2. After you have completed the listing as a class, select a small group to write a letter to these persons asking them to tell you what they think the most important energy sources/conversions will be by 2050. You might wish to send a list of the sources you generated in activity #1 in the form of a survey. Be sure to add space for them to add sources that you may not have thought of.

3. Send the letter/survey out to these persons. Make every effort to have an even distribution of types of people in your mailing: from inventors to politicians, service persons (e.g., plumbers and electricians. to academic persons (e.g., research engineers, technology education leaders, etc.). Be sure to include people who are known nationally and internationally in your survey as well as local people.

4. After the responses have been received, analyze them as a group and come to some agreement about the three most likely sources/conversions for the year 2050.

5. At this point, break up into small groups and assume the role of inventors. Assume that the energy sources that you have to work with are those identified from responses to your letters. Expand the listing of energy outputs that you developed in Activity #1 to include any other forms that you think may be possible or needed by 2050.

6. Your job as an invention team is to invent a contraption, mechanism, or device that will convert the energy source to an energy output (see Figure #9).

YOUR TASK

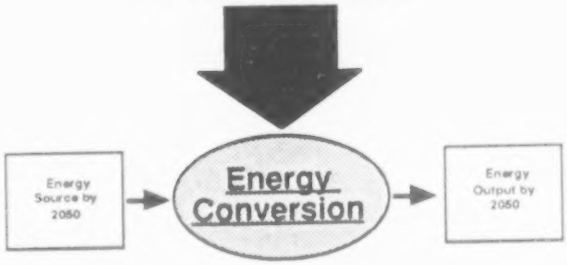


Figure #9 - Conversion Diagram

7. Narrow your task to one energy source and one energy output. An example could be ocean water as an energy source and electrical energy as the energy output need.
8. As a group, "invent" the conversion device. A word of caution at this point. You may not feel like you are knowledgeable enough to be able to actually invent something that will actually work. That's okay. What you are to do is to take a "black box" approach and simply speculate on the kinds of internal mechanisms, processes, or parts that you think would be needed for the device to accomplish what you desire it to do. Be as creative as you can. Use the broad range of knowledge that you have obtained from your Industrial Technology Education studies. Also, do not hesitate to tap into outside resources such as knowledgeable persons, books, articles, other devices that you could disassemble to see how they work, etc.
9. Develop a schematic/drawing of your conversion device. You may like to know that many early inventions were actually patented by individuals whose devices were in the stage of development that yours are in now.
10. If possible, you may wish to extend yourself beyond the "black box" level and actually construct a working prototype of your device at this point.
11. Develop a display of your conversion device; set it up as it would exist in a part of a larger system. For example, if you plan to convert ocean water (as your energy source) to power an automobile (mechanical energy output), then your display would need to picture your "converter device" in an automobile system (e.g., under the hood or in some other configuration).
12. Each group should make a presentation of their invention to the class.
13. Arrange to expose your invention to a larger group, such as in an all-school display case, an all-school convocation, a bank or local business, at the State Industrial Technology Education contest, etc. This can be done on a competitive basis where the best display or invention in the class is given the opportunity to make the presentation or present the display.

TAM #10 - Handouts

- Student component of TAM #5
- Instructional Sheet: The Stirling Engine - Operational Principles

TAM #10 - Summary

1. **Review Questions -- Test yourself!**
   - A. Explain what is meant by energy conversion.
   - B. What is meant by efficiency when considering energy conversion?
   - C. What is the difference between an internal and an external combustion engine?
   - D. What are the most efficient forms of energy conversion? Which of these are possible and realistic solutions for our energy supply needs?
   - E. Are there differences between conversion that are efficient in terms of energy but expensive in other ways, such as economic costs, risk to the environment, risk to human health, etc.? What are some examples?

TAM #10 - Post-assessment

Instructions:

1. Complete the post-test for TAM #5.
2. Have the instructor review the results from the experiments performed in each of the activities.

Course: Introduction to Energy & Power Technology

Technology Activity Module #6

Physics Revealed/Made Useful

by: Michael J. Dyrenfurth

E-MC²
C = Q / M(Tf-Ti)
-CwMw (Tf(w)-Ti(w))
ΔTs = ?

TAM #6: Physics Revealed/Made Useful

Instructor Component

Activity Objectives: Technology is inherently based on physics. As such, it is important that students understand some of the key principles of physics and how they work in order to be able to explain technology's operation. This TAM seeks to highlight two major aspects of physics. These are, heat and electromagnetism. By completing the activities in this TAM, students will have a basic understanding of heat, conduction, its effect on materials, and the effect of temperature differences. With respect to electromagnetism, students will understand electron flow, polarity, and magnetic lines of force.

Activity Competencies: By completing this TAM, the student will be able to:

1. Describe the relationship between physics and key technological applications.
2. Explain the effects of heat conduction and show applications in the world of technology.
3. Differentiate between conductors and insulators of heat.
4. Describe the effects of temperature differential on heat transfer.
5. Describe electron flow in electrical circuits.
6. Describe the rules for identifying directions of magnetic lines of force.
7. Identify the polarity of a spark.
8. Describe how magnetic lines of force affect technological applications.

Module Instructions

Introduction:

This module will introduce students to two major physical concepts in detail. These concepts, heat and electromagnetism, are but two of the many areas of physics that could have been addressed in this module. Be sure to identify, and have ready, examples of technological applications that depend on these concepts for their effective use.

Safety Considerations:

Although this is generally a safe module, students need to be reminded of the dangers of handling hot objects. Additionally, since there may be an open flame, be sure there are no combustible materials in the vicinity of the flame. Students should be cautioned not to wear flammable clothes when they perform the experiments outlined herein. With respect to the TAM's magnetic lines of force activity, only low voltage is to be used (less than 24 volts A.C.); consequently, it is a relatively safe activity as well. Nevertheless, caution students against contact with open circuits.

Needed Materials:

1. **Supplies Required**
   A. Strips of metal (may be nickel-silver), copper, lead, glass and wood 10" X 1/2" X 1/16"
   B. 1/4" cylinders of wax cut from a wax candle or crayon
   C. Iron filings
   D. Clear plastic/glass sheet

2. **Equipment/Machines/Tools**
   A. Propane torch or alcohol burner
   B. Electronic temperature readout/thermometer
   C. Tesla coil
   D. Automotive ignition system mockup (working)

3. **Handouts**

   Student component of TAM #6

4. **Instructional Resources**
   A. Catalogs

      Edmund's Scientific Catalog

   B. Books

      ______. (1989). Physics & technology education: Learning materials for secondary level. A project of the Asia-Pacific Physics Teachers and Educators Association, supported by UNESCO. Oregon City, Phillippines: Author.

Management/Logistics:

1. **Related TAMS**
   - Problem Solving TAM #2 (Materials and Processing Guide)
   - Research and Development/Experimentation TAM #3 (E&P Guide)

2. **Evaluation/Grading**
   A. The basic process to be rewarded in this TAM is strict adherence to the scientific method and accuracy of experimentation. Assign extra points for the control of variables over and beyond the basics. Neatness in reporting results is also critical.
   B. Additional points should be assigned for the merits of the discussion regarding the results.

3. **Suggested Schedule/Time**

   This TAM can be completed in one or two class periods.

Key Instructional Suggestions:

1. **Safety**

   Demonstrate how to perform Activity #1, The Mysteries of Heat Activity, and show students how to light the alcohol burner and/or propane torch. Highlight the need to keep the propane torch pointed away from any flammable objects and/or people. Demonstrate how to turn the propane torch down to its minimum, yet safe, operating level. If using an alcohol burner, guard against knocking it over and ensure that all students are aware of the flammability of clothing.

2. **Motivation**

   Knowledge is power. Explain to students that understanding these basic principles helps them create more efficient air conditioning units for their home or car, enables them to protect their hot-rods against overheating, and enables them to understand the intricacies of electromagnetic machines, motors, and actuators.

3. **Prerequisite Information**

   None.

4. **Demonstrations**

   A. Heat experiment

   B. Spark polarity assessment

   C. Magnetic lines of force display

5. **Reinforcement**

   A. This TAM is clearly an opportunity for the technology teacher and the science/physics teacher to interact extensively. Science teachers may very well have exemplary demonstration equipment available or, alternatively, the technology teacher and the science teacher could interact cooperatively to produce new equipment.

   B. The technology teacher should make a deliberate effort to reinforce those basics of scientific procedures that the science teacher wishes to accomplish.

6. **Attitudes**

   The key attitudes to be developed here are precision, systematic nature, consistency, and accuracy.

7. **Remediation/Enrichment**

   Remediation: Slower students should be assigned to work in pairs with faster students and be provided more discussion time to draw out the actual implications of the experiments.

   Enrichment: Faster students should be assigned the problem of controlling the variables to a better degree or making more difficult measurements with more sophisticated apparatus.

8. Summary & Review

- A. Heat conduction
- B. Differing material heat transfer rates
- C. Effective temperature on heat transfer
- D. Spark polarity
- E. Magnetic lines of force

9. Review Questions & Answers

A. Of the many forms of heat transfer, heat _______ is the mechanism used to sense heat by touch. (*Conduction*)

B. Differing materials have differing rates of heat transfer. Among the most important advantages of wood is its ______ rate of heat transfer. (*Low*)

C. The amount of heat transfer, after controlling for material, depends on_____. (*The difference in temperature between hot and cold ends*)

D. Electric current jumps a gap equally well in either direction (positive to negative or negative to positive). True or False? (*False*)

E. Magnetic lines of force represent imaginary lines that influence other materials. True or False? (*True*)

Date: ________ Class: ________ Name: ____________________________

TAM #6: Physics Revealed/Made Useful - Pre-test

Instructions: Indicate whether the following statements are **True** or **False** by placing either a **T** or an **F** in the blank provided.

_______ 1. Heat conduction is the same characteristic as heat radiation convection.

_______ 2. All synthetic and non-metallic materials transfer heat at the same rate.

_______ 3. Larger temperature differences mean slower heat transfer.

_______ 4. Gold has one of the highest heat transfer rates.

_______ 5. As a general rule, metals transfer heat better than nonmetallic materials.

_______ 6. Electrons always flow in the same direction.

_______ 7. Electromagnetic lines of force move in the same direction and axis as electrons.

_______ 8. One can visualize electromagnetic lines of force as being invisible lines radiating around a wire penetrating space.

Date: ______ Class: ________ Name: ________________________

TAM #6: Physics Revealed/Made Useful - Post-test

Instructions:

The post-test assessment is a rating form that students and instructors use to evaluate the experiment reports submitted by each student.

Experiment Rating Form

	Student Rating *	Instructor Rating *
1. The purpose of the experiment was described.		
2. The experimental variables were discussed.		
3. The error and control variables were discussed.		
4. The experimental apparatus was described and illustrated.		
5. The experimental procedure and data collection were described.		
6. The collected data were presented clearly.		
7. The analysis procedure and findings were clear.		
8. The conclusions were explicitly presented and discussed.		
9. Problems with the experiment and suggestions for further research were presented.		
Total Points		

* 0 = Not Done, or very inadequate   1 = Marginal   2 = Satisfactory   3 = Strong   4 = Superior

TAM #6: Physics Revealed/Made Useful - Test Keys

TAM #6 - Pre-test Answers

1. F 2. F 3. F 4. T 5. T
6. F 7. F 8. T

TAM #6 - Post-test Answers

The rating form is used as the post-test.

TAM #6: Physics Revealed/Made Useful

Student Component

Introduction:

Don't you ever wonder why things happen the way they do? Why, for example, does your car overheat? Why is cooling such a critical function in racing cars? How can one keep a house more cool by design rather than by pumping in a larger amount of air conditioning at great expense? Wouldn't it be nice to know enough about heat and its operation to be able to control it in our technological world?

This TAM first introduces you to some of the basics of heat transfer, which is so important in today's world. The second part of this TAM begins exploring the mysteries of electronics and electromagnetic lines of force. Yes indeed, these are the lines that make electric movement possible in motors, power devices, cars, airplanes, and the like. By completing this, you will have much better insight as to why things happen and then, when things break down, you will be in a much better position to troubleshoot and have the repairs made.

Competencies:

Following the completion of this TAM, you will be able to:

1. Describe the relationship between physics and key technological applications.
2. Explain the effects of heat conduction and show applications in the world of technology.
3. Differentiate between conductors and insulators of heat.
4. Describe the effects of temperature differential on heat transfer.
5. Describe electron flow in electrical circuits.
6. Describe the rules for identifying directions of magnetic lines of force.
7. Identify the polarity of a spark.
8. Describe how magnetic lines of force affect technological applications.

Module Overview:

Knowledge is power. Knowing about physics helps you explain technology and troubleshoot. A little attention to the basics will provide skills and understandings that you can use forever in solving technological problems.

Key Information:

1. Class Presentations

- Heat Transfer
- Conduction
- Radiation
- Convection

- Electromagnetism
- Current flow
- Right/left hand rule
- Nature of magnetism

2. **Demonstrations**
    - Heat conduction experiment
    - Spark polarity assessment
    - Magnetic lines of force display

3. **Safety**
    - Laboratory Safety
    - Lighting the burners

    Note the need to keep the propane torch pointed away from any flammable objects and/or people. Turn the propane torch down to its minimum, yet safe, operating level. If using an alcohol burner, guard against knocking it over, and be sure that you are not wearing flammable synthetic clothing.

4. **Personal Activity**
    - Contact your science teacher and review the units on heat and on electromagnetic lines of force that he/she has in your school science curriculum.
    - Go the the library and research both heat conduction and electromagnetic lines of force. Prepare a short, informal working draft summary of the key points that you have gotten from encyclopedias and other sources.
    - Obtain a bibliography of Nicholas Tesla and scan it to identify the many inventions of this man.

Glossary:

1. **Conduction** -- The movement of heat within a solid material.
2. **Convection** -- The transfer of heat by the circulating flow of a liquid or gas between a heat source and a heat sink.
3. **Differential** -- The difference between two things, characteristics, or places.
4. **Heat** -- The energy of atomic motion.
5. **Heat Transfer** -- The rate at which heat moves from one plane to another.
6. **Magnetic Lines of Force** -- Invisible lines of force generated around a magnet or current-carrying electric conductor.
7. **Polarity** -- The relative amount of positive or negative charge of one thing compared to another.
8. **Radiation** -- The transfer of heat through space by electromagnetic waves.
9. **Tesla Coil** -- A coil with an extended core designed to create linear magnetic lines of force.

Needed Materials:

1. **Supplies Required**
   - A. Strips of metal (may be nickel-silver), copper, lead, glass and wood 10" X 1/2" X 1/16"
   - B. 1/4" cylinders of wax cut from a wax candle or crayon.
   - C. Iron filings
   - D. Clear plastic/glass sheet

2. **Equipment/Machines/Tools**
   - A. Propane torch or alcohol burner
   - B. Electronic temperature readout/thermometer
   - C. Tesla coil
   - D. Automotive ignition system mockup (working)

3. **Handouts**

   Student component of TAM #6

TAM #6: Physics Revealed/Made Useful

Activity #1: The Mysteries of Heat - Plan of Procedure

1. Mount the sample material strips as shown in the diagram (Figure #1).

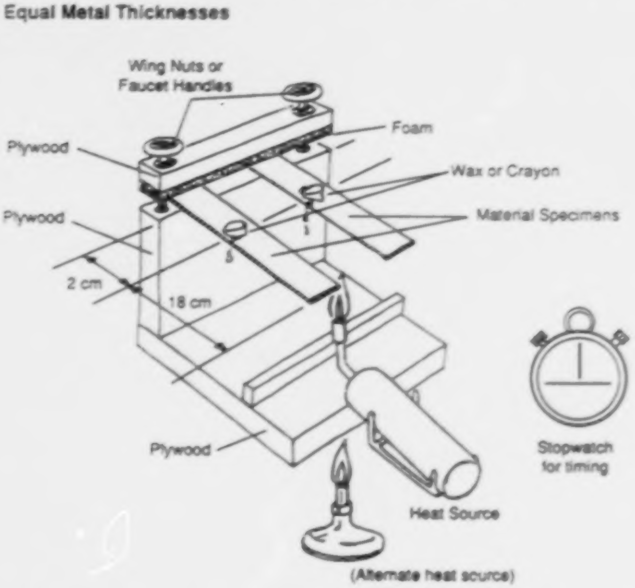

Equal Metal Thicknesses
Wing Nuts or Faucet Handles
Foam
Plywood
Wax or Crayon
Plywood
Material Specimens
2 cm
18 cm
Plywood
Stopwatch for timing
Heat Source
(Alternate heat source)

Figure #1 - Heat Conduction Experimental Setup

2. Cut wax cylinders and place exactly two centimeters from the clamp's edge, as shown.

3. Light the alcohol burner and adjust it to a steady low flame. Position the alcohol burner so that the center of its flame is exactly 18 cm. from the center of the wax cylinder. The tip of the cone should stop just short of touching the metal strip, and it should be centered left to right.

4. The instant you place the alcohol flame underneath the metal strip, start a stop watch and record the time until the wax cylinder has completely melted (no edge shows).

5. Repeat this step for each different sample of material to be tested. Because of different heat conduction rates, the time taken for the wax to melt will vary.

6. Identify other variables that need to be controlled in order to make this experiment more accurate, e.g., drafts that affect the heat applied to each specimen.

7. Write up your experiment results in a way that identifies systematic conclusions regarding the type of material and heat transfer rates.

8. Repeat this experiment using a specimen of triple thickness of any one of the materials (Figure #2).

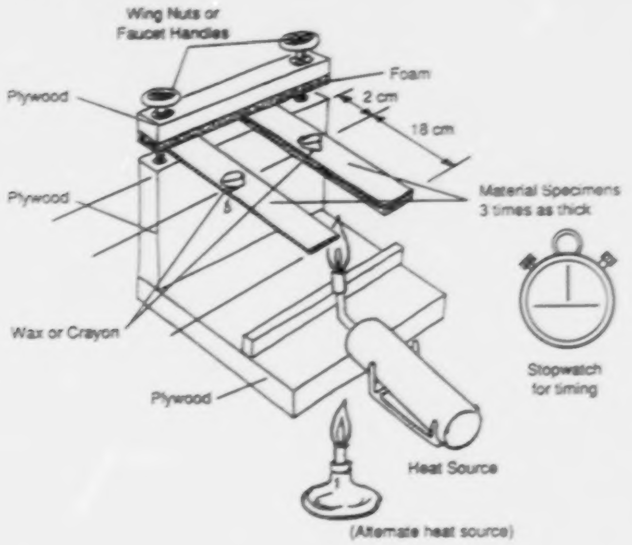

Unequal Metal Thicknesses
Wing Nuts or Faucet Handles
Foam
Plywood
2 cm
18 cm
Plywood
Material Specimens 3 times as thick
Wax or Crayon
Stopwatch for timing
Plywood
Heat Source
(Alternate heat source)

Fig. 2 - Heat Conduction Experimental with Thicker Sample

9. Discuss the results you have obtained this time in comparison to the previous experiment.

10. Increase the alcohol flame to double or triple its original volume as set up in the first part of this activity.

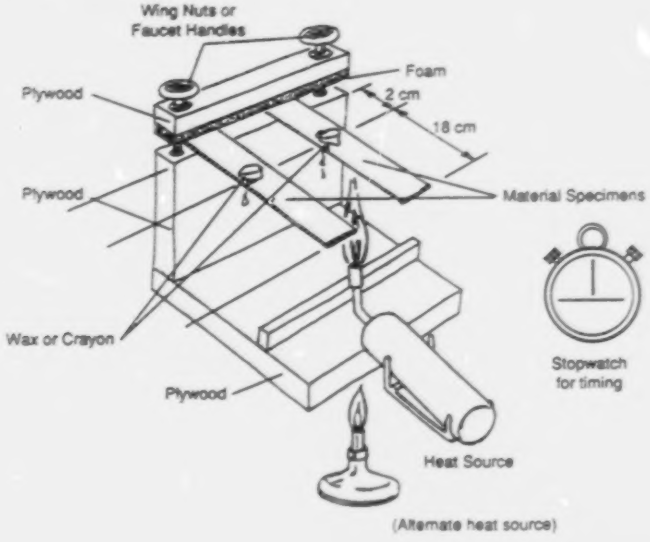

Hotter Heat Source
Wing Nuts or Faucet Handles
Foam
Plywood
2 cm
18 cm
Plywood
Material Specimens
Wax or Crayon
Stopwatch for timing
Plywood
Heat Source
(Alternate heat source)

Fig. 3 - Heat Conduction Experimental Setup with Intensified Flame

11. Repeat the experiment using this much hotter flame and record the results.

12.. Compare the results to those of the first round in the experiment.

13. Develop a descriptive narrative that identifies clearly the experimental results and the effects of thickness of material and temperature differences on heat transfer.

TAM #6: Physics Revealed/Made Useful

Activity #2: The Mysteries of Electromagnetism - Plan of Procedure

1. Operate the automobile engine system demonstrator and notice the spark arcing across the spark plug (Figure #4).

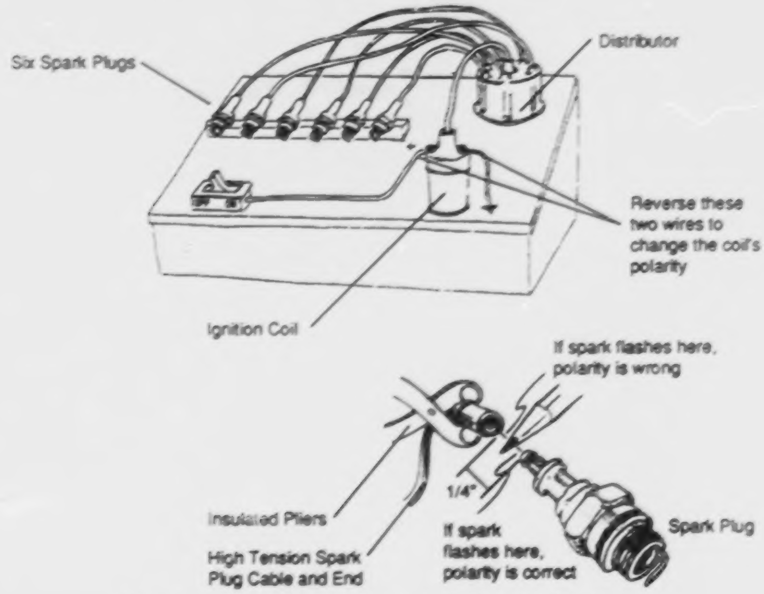

Six Spark Plugs
Distributor
Reverse these two wires to change the coil's polarity
Ignition Coil
If spark flashes here, polarity is wrong
1/4"
Insulated Pliers
High Tension Spark Plug Cable and End
If spark flashes here, polarity is correct
Spark Plug

Figure #4 - Spark Demonstration Unit

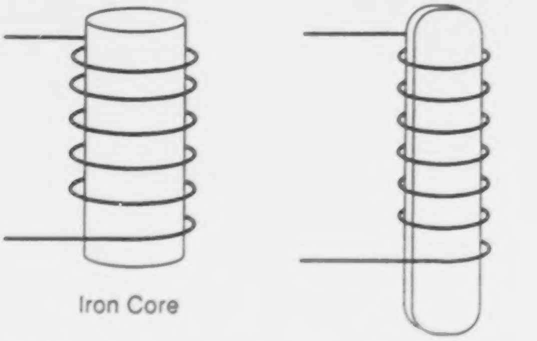
2. Using insulated pliers and gloves, remove the high tension lead from one of the spark plugs and hold it adjacent to a ground. Notice the spark jumping between the end of the high tension lead and ground.

3. Place a pencil between the high tension lead and the ground. Notice on which side of the pencil the spark occurs. If the spark flames on the ground side, the polarity of the coil is correct. If the spark flames between the wire and the pencil, the coil's polarity is incorrect.

4. Reverse the polarity of the wires on the ignition coil and repeat this process. Notice the spark occurs on the opposite side of the pencil. This is known as spark polarization. When the spark jumps from a positive to a negative ground, it requires much less voltage than the reverse. Hence, your ignition systems can be more effective.

5. But spark polarity is not sufficient, however, to explain the mysteries of electromagnetism. However, it is clear that it demonstrates movement of a flow of current. But what and where are the electromagnetic lines of force?

6. Build a simple electromagnet as shown in the diagram (Figure #5).



Iron Core

(Insulated wire, approximately ten turns of #24 wire)

Tongue Depresser or Wood Strip

Figure #5 - Electromagnet

7. Connect the electromagnet to a 12-volt D.C. current-regulated power supply and permit a small amount of current to go through the electromagnet. Position the electromagnet just underneath a 1/16" Plexiglass surface and sprinkle some magnetic filings on the Plexiglass plate (Figure #6).

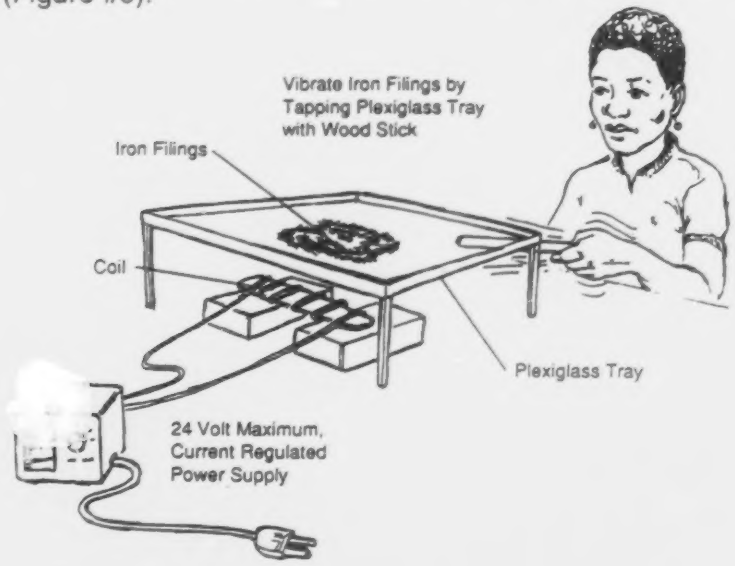

Vibrate Iron Filings by Tapping Plexiglass Tray with Wood Stick
Iron Filings
Coil
Plexiglass Tray
24 Volt Maximum, Current Regulated Power Supply

Figure #6 - Iron Filing Line of Force Experimental Setup

8. Vibrate the blade lightly by tapping a pencil and/or an eraser until the electromagnetic lines of force show by means of the iron filing patterns.

9. Draw some conclusions based on the patterns and the orientation of the wires in the electromagnet. Formally write these conclusions down on paper and/or sketch them.

10. Consult a physics book and confirm or correct the conclusions you have identified in the previous step.

11. Electromagnetic lines of force seem almost obvious. For example, take a magnet and try and pick up a piece of ferrous material with it. Notice the magnet is drawn to the ferrous material (Figure #7).

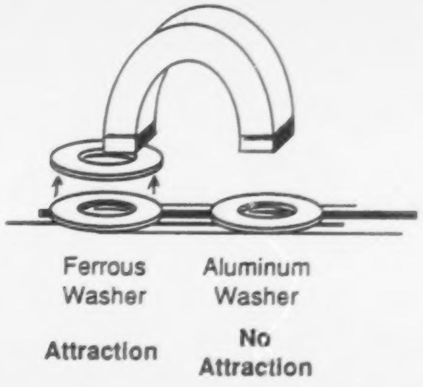


Figure #7 - Magnetic Attraction

12. Use the same magnet and try to pick up and aluminum washer with it (maybe one you have cut out of aluminum). Notice that the magnetic lines of force do not attract the aluminum as they do the ferrous material.

13. Take the Tesla coil and make sure the power is OFF.

14. Now place the aluminum washer over the Tesla coil vertical finger (Figure #8).

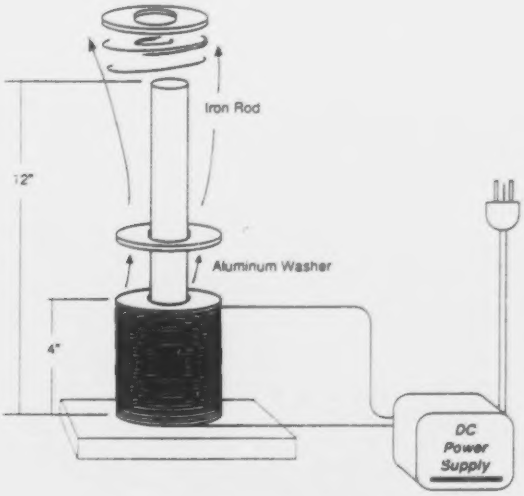


Figure #8 - Tesla Coil

15. Turn on the power to the Tesla coil - what happened?

16. Write a short explanation indicating why the aluminum washer was moved by the magnetic lines of force, although the aluminum is clearly not attracted to a magnet. Take the short description to your science/physics teacher and have him/her verify your conclusions.

TAM #6 - Summary

1. **Review & Summary Activities**
   - A. Review your activity notes and make sure they clearly present what went on.
   - B. Have your teacher review your notes and grade them accordingly.
   - C. Extend your knowledge to new areas. Identify new applications for heat transfer and new applications for magnetic lines of force that weren't dealt with previously.

2. **Review Questions -- Test yourself!**
   - A. How is heat transfer by conduction different from heat transfer by convection?
   - B. Identify an example where it is important to have good heat transfer and another one where it is important not to have good heat transfer.
   - C. Why is it important not to have magnetic lines of force working around a computer?

TAM #6 - Post-assessment

Instructions:

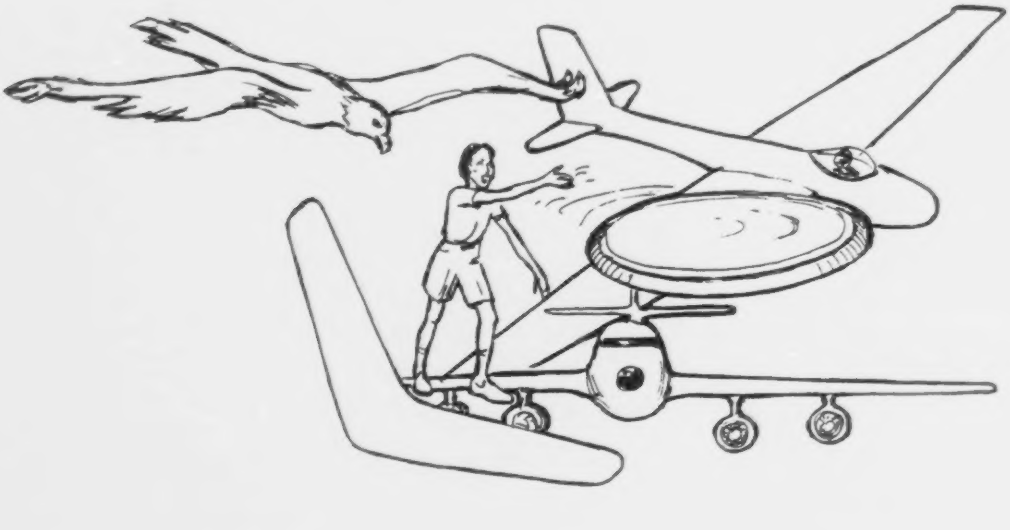
Review class notes and your experiment report and use the rating form to check yourself. Then give it and your report to the instructor for grading. After it is returned, discuss any differences in the two ratings.

Course:	Introduction to Energy & Power Technology

Technology Activity Module #7

Adventures in Flight

by: Steve Murray



TAM #7: Adventures in Flight

Instructor Component

Activity Objectives: The primary purpose of this TAM is to introduce the student to flight principles and aeronautics. Students will learn about the four forces that act on an airplane in flight as well as the four basic airplane motions. These fundamentals of flight will be learned through classroom and laboratory activities.

Activity Competencies: By completing this TAM, the student will be able to:

1. List and define the four forces that act on an airplane in flight.
2. Identify key parts on an aircraft.
3. Complete definitions for terms related to flight aerodynamics and control principles.
4. Demonstrate the safe and proper use of energy & power technology tools, equipment, materials, and processes.
5. List and define the three components of any transportation system.
6. Complete statements concerning the historical events of flight.
7. Complete statements concerning the future of flight and flight aerodynamics.
8. List, identify, and define the three basic motions of aircraft in flight.

Module Instructions

Introduction:

Since the dawn of time, people have wished they could fly. Relatively little time has passed since the first flight of the Wright brothers. The sky, we might say, is **not** the limit!

This TAM is designed to introduce students to flight through four laboratory activities. Each of these activities presents the students with a different experience related to flight. The activities include construction of a glider, airplane construction and flying, flying an airplane on a computer flight simulator, and flying a line-controlled model airplane.

Safety Considerations:

- The students are to wear safety glasses at all times during laboratory activities and line-controlled airplane flight.
- Students are encouraged to observe and follow all basic equipment operating safety rules established by the instructor.

Needed Materials:

1. **Supplies Required**
   - A. Glider Construction
     1. 3/16" x 2" balsa
     2. 3/16" x 1/2" balsa
     3. 1/16" x 1 1/2" balsa
     4. 22 gauge sheet metal (nose weight)
     5. Sandpaper
     6. Hot glue

Bulk balsa may be ordered from:
Frank Paxton Lumber Company
6311 St. John Avenue
Kansas City, MO 64123
1-800-892-3083

B. Airplane construction

1. Balsa Airplane Kits (lab pack of 35) and Airplane Modeler's glue

Order from:
Midwest Products Co., Inc.
400 S. Indiana St.
P.O. Box 564
Hobart, IN 36342

or

2. Whitewings Airplane Assembly Kits (lab pack of 15)

Order from:
Creative Learning Systems, Inc.
9899 Hibert, Suite C
San Diego, CA 92131
1-800-458-2880

C. Computer Flight Simulation: Flight Simulator Software

1. IBM - Chuck Yeager's Advanced Flight Trainer
Microsoft's Flight Simulator Ver. 4.0

Order from:
CompuAdd Corp.
12303 Technology Boulevard
Austin, TX 78727
1-800-626-1967

2. Apple - Sublogic's Flight Simulator II

Order from:
Software Discounters of America
P.O. Box 111327-Dept. CP
Blawnox, PA 15238

3. Apple - Glide/Path

Order from:
Creative Learning System, Inc.
9899 Hibert; Suite C
San Diego, CA 92131
1-800-458-2880

4. Apple - Flight

Order from:
PITSCO
P.O. Box 1328
Pittsburg, KS 66762

D. Line-Controlled Flight:

Line-controlled airplane
Starter kit for line-controlled airplane
(Can be purchased from most hobby or department stores)

2. Equipment/Machines/Tools

A. Glider Construction
1. Hot glue gun
2. Glue blocks
3. Jig, scroll, or band saw
4. Tin snips
5. Sheet metal hand folders or pliers

B. Airplane Construction

Hobby knife

C. Computer Flight Simulation

IBM or Apple Computer System

D. Line-controlled Flight
1. Airplane and engine
2. Smooth surface for take-off and landing

3. Handouts

A. Student component of TAM #7
B. Instruction Sheet for operating computerized flight simulator (to be developed to match the computer system/program).
C. Flight Instructional Sheet
D. Glider Pattern Sheet

4. Instructional Resources

A. Books
1. Anderson, J.D. Jr. (1985). Introduction to flight. New York: Gregg Division - McGraw-Hill Book Company.

2. Ashley, S. (1988, October). Jump jet. Popular Science, p. 56-59, 112[illegible]4.
3. Boyll, C.L. (1988). Fighter jets: Ready-to-build-and-fly model aircraft. Blue Ridge Summit, PA: TAB Books Inc.
4. Cole, T. (1989, October). Irresistible force. Popular Mechanics, p. 59-62.
5. Gilmore, C.P. (1989, October). B-2: What stealth's first flight reveals. Popular Science, p. 45-49, 90.
6. Jones, J. (1989). Stealth technology: The art of black magic. Blue Ridge Summit, PA: TAB Books Inc.
7. Kroes, M.J., J.R. Rardon, R.D. Bent, and J. L. McKinley. (1989). Aircraft basic science. New York: Gregg Division - McGraw-Hill Book Company.
8. Old, A.R. De, E. Sheets, and W. Alexander. (1986). Transportation: The technology of moving people and products. Worcester, MA: Davis Publications, Inc.
9. Schefter, J. (1989, February). X-31: How they're inventing a radical new way to fly. Popular Science, p. 58-64.
10. Siuru, B. and J.D. Busick (1987). Future flight: The next generation of aircraft technology. Blue Ridge Summit, PA: TAB Books Inc.
11. Smith, H. (1985). The illustrated guide to aerodynamics. Blue Ridge Summit, PA: TAB Books Inc.

B. Film slides/film/video

1. In the Cockpit (6 video series) and Action Video (3 video series) from:

   Easton Press Video
   47 Richards Avenue
   Norwalk, CN 06857
   1-800-367-4534

2. X-Planes, Test Pilot, Future Flight: Tomorrow's Airliner, etc., may be ordered from:

   Aviation Week Video
   P.O. Box 308
   Mt. Olive, NJ 07828
   1-800-433-0880

3. Thunderbirds and Blue Angels videos and more may be ordered from:

   ARP Videos
   Dept. A
   3349 Cahuenga Blvd. West
   Suite 4-A
   Hollywood, CA 90068
   1-800-VIDEOS-2

4. Educational films and slides are available from:

   Air Force Office of Youth Relations
   Kelly AFB, TX 78241-5000
   512-925-5384

5. A weekly series airs on the Discovery channel called "WINGS". The series concentrates on a different aircraft each week.

C. Magazines

1. Air & Space Smithsonian
   Smithsonian Institution
   Membership-Subscription Center
   P.O. Box 51244
   Boulder, CO 80321-1244

2. Aviation Week & Space Technology
   P.O. Box 503
   Hightstown, NJ 08520-9899

D. Poster, pictures, and information pamphlets

1. Federal Aviation Administration
   800 Independence Ave. S.W.
   Washington, DC 20591

2. Cessna Aircraft Company
   Air Age Education Dept.
   P.O. Box 1521
   Wichita, KS 67201

3. American Airlines Flight Academy
   P.O. Box 619617
   DFW Airport, TX 75261-9617

4. McDonnell-Douglas Aircraft Co.
   Public Relations Dept.
   St. Louis, MO 63166

Management/Logistics:

1. Related TAMS

This TAM is independent of others.

2. Evaluation/Grading

A. Glider - accuracy in construction and flight performance.
B. Airplane - accuracy in construction and flight performance.
C. Computer Flight Simulation - none.
D. Line-Controlled Flight - ability to control the airplane properly.

3. Suggested Schedule/Time

The time suggested for this TAM is one to two weeks.

Key Instructional Suggestions:

1. Safety

A. Wear safety glasses when in the lab or flying the line-controlled airplane.
B. Follow specific safety rules regarding the use of equipment.

2. Motivation

A. Video materials about military aircraft.
B. Place posters and pictures of aircraft on the walls of classroom.

C. Display plastic models of various types of aircraft.
D. Guest speaker on pilot training and flight.
E. Field trip to a local airport.

3. Prerequisite Information

None required.

4. Demonstrations

A. Balsa glider in flight.
B. Demonstrate the three airplane motions (pitch, yaw, and roll) using a large styrofoam glider in flight after placing control surfaces on wings and tail.
C. Airplane (rubber-band) in flight.
D. Operation of the flight simulator on the computer. It may also be necessary to demonstrate the general operation of the computer.
E. Demonstrate the operation of the line-controlled airplane.

5. Reinforcement

This TAM reinforces some of the basic principles of physics.

6. Attitudes

A. Excitement is good in some activities, but remind students that patience has its own rewards.
B. Students should concentrate on their activity.
C. Students should observe equipment-operating safety rules at all times.

7. Remediation/Enrichment

Remediation: Provide students with informational pamphlets concerning flight principles.
Enrichment: Students could research new aircraft designs and then do some preliminary design for their own aircraft.

8. Summary & Review

In this TAM, students construct a glider, an airplane, operate a computerized flight simulator, and fly a line-controlled airplane. Throughout these activities, students are introduced to the history of flight and some of its possible futures. The following should be reviewed before completing this module:

A. The four forces on an airplane in flight.
B. The three basic notions for an airplane.
C. Historical events concerning flight.
D. Futuristic applications of flight.
E. Basic parts of aircraft.

9. Review Questions & Answers

A. What are the three basic motions of an airplane in flight? (*pitch, roll, and yaw*)

B. Define pitch. (*movement of an airplane diving or climbing*)

C. The body of an airplane is known as __________. (*fuselage*)

D. __________ __________ was the first person to fly faster than the speed of sound. (*Chuck Yeager*)

E. The __________ __________ flew the first airplane on December 17, 1903. (*Wright Brothers*)

F. List 3 basic control surfaces on an airplane. (*ailerons, elevators, rudders or flaps*)

G. List the 4 basic parts to your glider. (*fuselage, fin, stabilizer, wing*)

Date: ________ **Class:** ________ **Name:** ______________________________

TAM #7: Adventures in Flight - Pre-test

Instructions: Answer the following questions.

1. List the three basic components of every transportation system.

2. List the four modes of transportation.

3. List four different types of air transportation.

4. List an important event in the history of flight.

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Date: ________ **Class:** ________ **Name:** ____________________________

TAM #7: Adventures in Flight - Post-test

Instructions: Describe each of the following statements as **True** or **False.**

___ 1. Aerodynamics is the science relating to the effects of air or other gases in motion.

___ 2. Drag is a moveable control surface attached to the trailing edge of a wing to control an airplane roll.

___ 3. Canards are moveable surfaces attached to the trailing edge of the wings to produce high lift surfaces designed to reduce the take-off and landing speeds of the aircraft.

___ 4. Dihedral is the upward angle of a wing as measured from horizontal on the lateral axis. The outer end of the wing is lower than the root end of the wing.

___ 5. Flaps are horizontal, hinged control surfaces, attached to the trailing edge of a horizontal stabilizer of an airplane, designed to control the airplane about the lateral axis.

Complete the following statements:

6. ___________ is the body of an airplane.

7. ___________ was the first airplane to break the sound barrier.

8. ___________ is an upward pressure equal to or greater than the weight of the air displaced by the object.

9. ___________ is the movement of an airplane diving or climbing.

10. Roll is the movement of an airplane ___________ without any change in direction.

11. ___________ is the movement of an aircraft about the vertical axis; turning left or right.

12. List the four forces that act on an airplane in flight.
    a. ____________________________________
    b. ____________________________________
    c. ____________________________________
    d. ____________________________________

TAM #7: Adventures in Flight - Test Keys

TAM #7 - Pre-test Answers

1. power plant, control system, and vehicle
2. air, water, land, and space
3. airplane, jet, balloon, blimp, helicopter, etc.
4. any major event in flight history.

TAM #7 - Post-test Answers

1. T 2. F 3. F 4. T 5. F

6. Fuselage
7. Bell X-1
8. Lift
9. Pitch
10. Twisting
11. Yaw
12. Drag, lift, thrust, and gravity

TAM #7: Adventures in Flight

Student Component

Introduction:

Imagine if you could go back in time and take your great-great-grandparent on a 747. What if you would have predicted a trip to the moon during the year in which they were born? No one would have believed you. Flight has come a long, long way!

This TAM is designed to introduce you to flight through four laboratory activities. Each of these activities presents you with a different experience for flight. The activities include construction of a glider, airplane construction and flying, flying an airplane on a computer flight simulator, and flying a line-controlled model airplane.

Competencies:

Following the completion of this TAM, you will be able to:

1. List and define the four forces that act on an airplane in flight.
2. Identify key parts on an aircraft.
3. Complete definitions for terms related to flight aerodynamics and control principles.
4. Demonstrate the safe and proper use of energy & power technology tools, equipment, materials, and processes.
5. List and define the three components of any transportation system.
6. Complete statements concerning the historical events of flight.
7. Complete statements concerning the future of flight and flight aerodynamics.
8. List, identify, and define the three basic motions of aircraft in flight.

Module Overview:

In the early years of flight, the quest for speed was the driving motive for aviators and pilots. That motive still exists today. The thought of going Mach 2, "with your hair on fire", is very exciting, to say the least. Perhaps you will someday fly faster than any other person alive. Record airspeed to date reaches upwards of 3,000 miles per hour. Now that's fast!

Key Information:

1. **Class Presentations**
    - Important historical events in the history of flight.
    - Four forces that act on aircraft in flight.
    - Three motions of an airplane in flight.
    - Basic airplane parts and their functions.
    - Future aircraft and their applications.

2. Demonstrations

- Balsa glider in flight.
- Demonstrate the three airplane motions (pitch, yaw, and roll) using a large styrofoam glider in flight after placing control surfaces on wings and tail.
- Airplane (rubber-band) in flight.
- Operation of the flight simulator on the computer.
- Line-controlled airplane demonstration.

3. Safety

- Wear safety glasses when in the lab or flying the line-controlled airplane.
- Follow specific safety rules regarding the use of equipment.

4. Personal Activity

As your homework, you should read about the history of flight and flight principles. Articles can be found in the school's library in magazines, newspapers, and books. Before starting laboratory activities, you should read the following:

A. Ashley, S. (1988, October). Jump jet. Popular Science, pp. 56-59, pp. 112-114.
B. Cole, T. (1988. October). Irresistible force. Popular Mechanics, pp. 59-62.
C. Gilmore, C.P. (1989, October). B-2: What stealth's first flight reveals. Popular Science, 90, pp. 45-49, 90.
D. Old, A.R. De, E. Sheets, and W. Alexander. (1986). Forces affecting flight. Transportation: The technology of moving people and products, pp. 310-325
E. Schefter, J. (1989, February). X-31: How they're inventing a radical new way to fly. Popular Science, pp. 58-64.

Glossary:

1. **Aerodynamics** -- The science relating to the effects of air or other gases in motion.
2. **Aileron** -- A moveable control surface attached to the trailing edge of a wing to control an airplane roll.
3. **Canard** -- An aircraft configuration having its horizontal stabilizing and control surfaces in front of the wings.
4. **Dihedral** -- The upward angle of a wing as measured from horizontal on the lateral axis. The outer end of the wing is lower than the root end of the wing.
5. **Drag** -- The retarding force acting upon a body in motion; wind resistance.
6. **Elevator** -- A horizontal, hinged control surface attached to the trailing edge of a horizontal stabilizer of an airplane, designed to control the airplane about the lateral axis.
7. **Fin** -- A common term for the vertical stabilizer
8. **Flaps** -- Moveable surfaces attached to the trailing edge of the wings to produce high lift surfaces designed to reduce the take-off and landing speeds of the aircraft.
9. **Fuselage** -- The body of the airplane.
10. **G Force** -- A unit of force equal to the gravity exerted on a body at rest.
11. **Knot** -- A rate of speed equivalent to 1 nmi/h (6076.1033 ft/h) [1852 m/h].
12. **Lift** -- An upward pressure equal to or greater than the weight of the air displaced by the object.
13. **Mach** -- Unit for airspeed; speed of sound is mach 1 or 660 mph.
14. **Pitch** -- Movement of an airplane diving or climbing.
15. **Roll** -- Movement of an airplane twisting without any change in direction.
16. **Rudder** -- A vertical control surface hinged to the tail post, aft of the vertical stabilizer, designed to apply yawing motions to the airplane.
17. **Thrust** -- A reaction force measured in pounds.
18. **Yaw** -- The movement of an aircraft about the vertical axis; turning left or right.

Needed Materials:

1. **Supplies Required**
   - A. Glider Construction
     1. 3/16" x 2" balsa
     2. 3/16" x 1/2" balsa
     3. 1/16" x 1 1/2" balsa
     4. 22 gauge sheet metal (nose weight)
     5. Sandpaper
     6. Hot glue
   - B. Airplane construction
     1. Balsa Airplane Kits (lab pack of 35) and Airplane Modeler's glue

        OR

     2. Whitewings Airplane Assembly Kits (lab pack of 15)
   - C. Computer Flight Simulation: "Flight Simulator" Software
   - D. Line-Controlled Flight:
     - Line-controlled airplane
     - Starter kit for line-controlled airplane

2. **Equipment**
   - A. Glider Construction
     1. Hot glue gun
     2. Glue blocks
     3. Jig, scroll, or band saw
     4. Tin snips
     5. Sheet metal hand folders or pliers
   - B. Airplane Construction
     - Hobby knife
   - C. Computer Flight Simulation
     - IBM or Apple Computer System
   - D. Line-controlled Flight
     1. Airplane and engine
     2. Smooth surface for take-off and landing

3. **Handouts**
   - A. Student component of TAM #7
   - B. Instruction Sheet for operating computerized flight simulator (to be developed to match the computer system/program)
   - C. Flight Instructional Sheet
   - D. Glider Pattern Sheet

TAM #7: Adventures in Flight

Activity #1: Glider Construction - Plan of Procedure

Each student will receive a pattern sheet for the glider that will be created in the laboratory. Follow the plan of procedure as you develop the glider.

1. Cut the patterns out with a pair of scissors.
2. Get balsa stock that is 1/16" thick.
3. Trace the fin and stabilizer patterns on the 1/16" balsa stock.
4. Cut the fin and stabilizer out of the balsa stock with either a band or scroll saw. Label the fin and stabilizer.
5. Get the balsa stock that is 3/16" x 2".
6. Trace the two wing patterns on the balsa stock.
7. Cut the wings out of the balsa stock with either the band or scroll saw. Label both parts "wing".
8. Get the balsa stock that is 3/16 " x 1/2" x 10 1/2".
9. Shape the fuselage as shown below with saw or sandpaper (Figure #1).

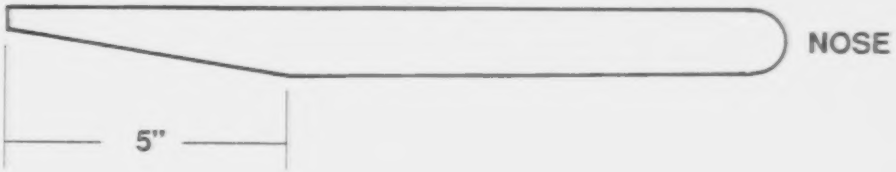


Figure #1 - Fuselage

10. Shape the wings with sandpaper to the shape shown below. This shape should be seen when you look at the end of your wing (Figure #2).

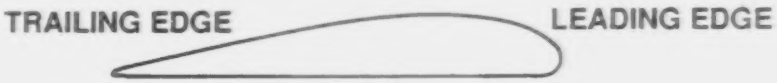


Figure #2 - Wings

11. Lay one wing on the table top and glue the other wing at a 30 degree angle to the wing laying on the table (Figure #3). Glue blocks cut to a 30 degree angle are very helpful.

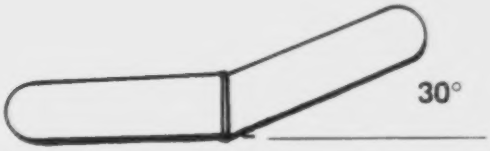


Figure #3 - Glue Setup

12. Measure and find the center of stabilizer and glue the fin to it (Figure #4).

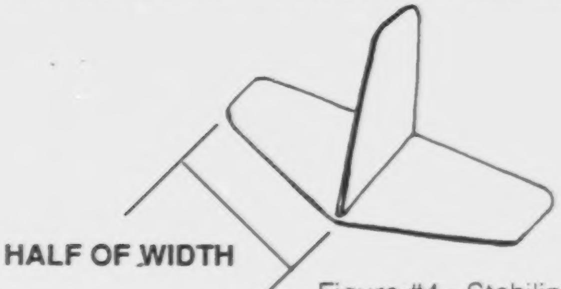


Figure #4 - Stabilizer Glue-up

13. Measure 3" from the front of the fuselage and place a mark on the fuselage at that point (Figure #5).

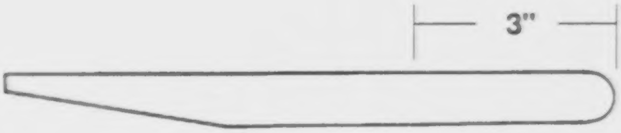


Figure #5 - Fuselage Measurement

14. Glue the wings to the fuselage. It is very important for the wings to be balanced evenly on the fuselage (Figure #6). Front, center of wings should be at the 3" mark on the fuselage.

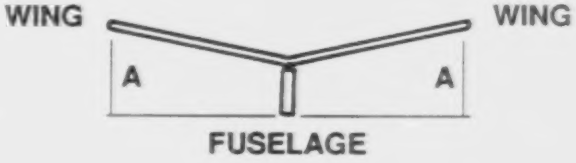


Figure #6 - Wing Glue-up

15. Glue the tail section (fin and stabilizer) to the rear end of the stabilizer (Figure #7).

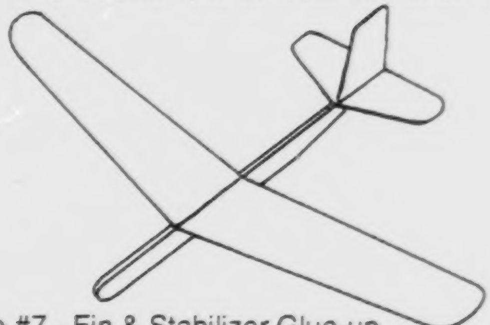


Figure #7 - Fin & Stabilizer Glue-up

16. Cut, shape, and attach a nose weight to the front of the glider.

17. Test fly it! Don't throw it very hard. A gentle toss usually is more successful (Figure #8).

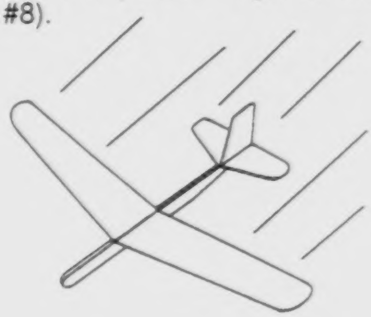


Figure #8 - Test Fly

18. Use tape and place control surfaces on your glider and experiment.

TAM #7: Adventures in Flight

Activity #2: Airplane Construction - Plan of Procedure

Each student will receive an airplane kit for their airplane construction. The airplane will be built in the laboratory. Follow the plan of procedure (given with the kit) as you develop the airplane.

1. Cut the balsa or paper pieces to shape.
2. Cut the tissue paper or card stock to the desired shape.
3. Assemble as shown in the assembly instructions.
4. Test fly it!

TAM #7: Adventures in Flight

Activity #3: Computer Flight Simulation - Plan of Procedure

Students work in pairs during the computer flight simulation. Students are to take turns in airplane control. You are encouraged to fly different airplanes throughout this activity. Each of you will be provided with a handout containing specific instructions for operating your flight simulator.

1. Place the program disk in the computer and turn the computer on.
2. Follow the start-up procedures for the flight simulator program.
3. Start take-off procedures for the flight simulator program.
4. Once you are in the air, you need to make the airplane perform the following motions:
   - roll (twist)
   - yaw (left and right)
   - pitch (up and down)
5. Experiment with acceleration during each of these motions.
6. Experiment with different types of aircraft, speeds, altitude climbing, etc.

TAM #7: Adventures in Flight

Activity #4: Line-Controlled Flight - Plan of Procedure

Students are to fly a line-controlled airplane for approximately 2-3 minutes. During flight, the students are to experiment with the control yoke producing airplane motions.

1. Place the airplane on a smooth surface to act as a runway for take-off.
2. Place fuel in the airplane's fuel tank. Only place enough for a few minutes of flight.
3. Using the spring mechanism, start the airplane's engine. Be sure to hold on to the airplane.
4. Have someone hold the airplane until you have returned to the yoke.
5. When you are ready to fly the airplane, tell the student to let go of the airplane.
6. During take-off, you should be careful not to climb or dive too quickly. Keep the yoke straight up and down.
7. Follow the airplane as it flies until it is out of fuel.
8. Once it is out of fuel, you should land the airplane on the landing surface.

TAM #7 - Summary

In this TAM you constructed a glider and airplane, operated a computerized flight simulator, and flew a line-controlled airplane. Throughout these activities, you were also introduced to the history of flight and some of its possible futures. Who knows what future aviation technology will hold?

TAM #7 - Post-assessment

Complete the post-test given by your instructor.

TAM #7 - Handout #1

Flight Instructional Sheet

On December 17, 1903, Orville and Wilbur Wright placed their names in the history books. They became the first human beings to fly with powered flight. Since that day, technologist have continuously improved aircraft science and aeronautics in an effort to achieve top speeds and altitudes. For example, on October 14, 1947, Air Force Captain Charles "Chuck" Yeager flew faster than sound in the Bell X-1, an experimental jet. Today, the Sr-7 flies 3 1/2 times faster than the speed of sound (660 mph). Secretly, the Air Force is supposedly developing an aircraft that will replace the SR-71 with speeds surpassing MACH 5.

One of the newest marvels in aviation is the B-2 Stealth bomber. Its technology makes it feasible to invade enemy territories without being detected. Now that is a scary thought! Modern aviation is advancing daily and changing our lives continuously. NASA is presently investigating the development of a commercial transport jet that will fly into space and back!

How does an airplane fly? If you look at the end of an airplane wing, you will find that it is shaped like an elongated "tear drop". This shape is known as an airfoil. This airfoil produces lift, which overcomes gravity, so that the airplane can fly. Lift results from a drop in air pressure on top of the wing as it moves through the air. Lift is achieved through the thrust of engines pushing the aircraft forward. These forces that we have just discussed are known as the four forces of flight (drag, thrust, gravity, and lift). (See Figure #9)

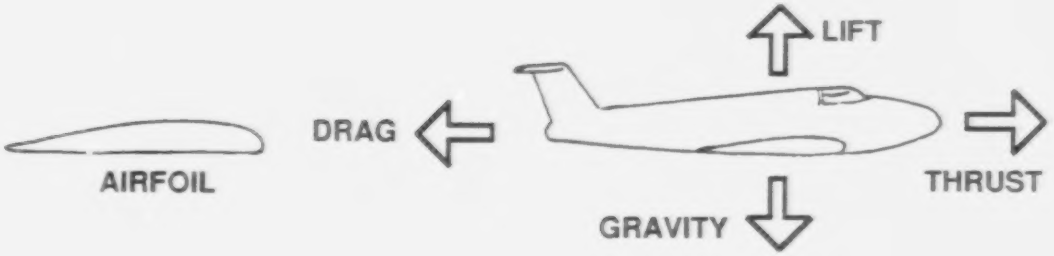


Figure #9 - Airplane Design Dynamics

During flight, an airplane produces three basic motions . These motions are roll, pitch, and yaw. Roll is when an aircraft twists during flight. Pitch is when an airplane's fuselage is pointed downward or upward. Yaw is a turning motion of an airplane to the left or right. These motions are produced by basic control surfaces such as ailerons, flaps, elevators, rudders, etc. Each of these control surfaces are illustrated in Figure #10 on the next page.

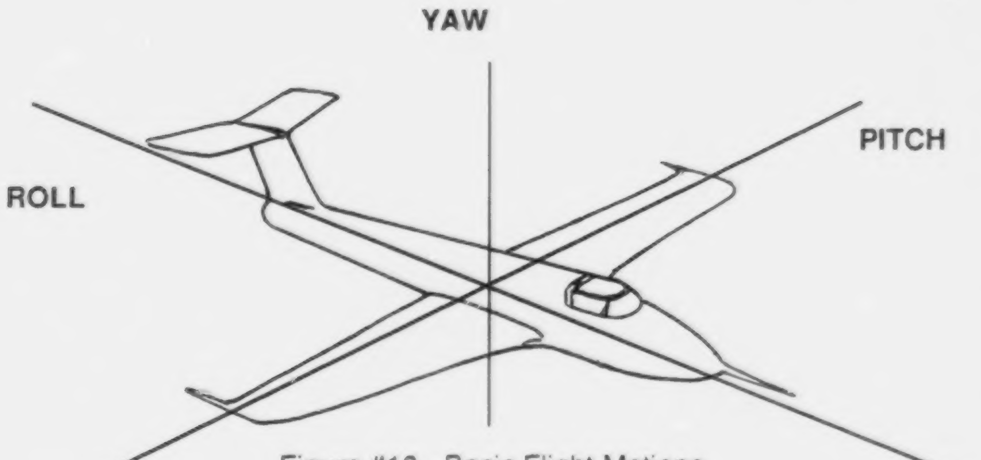

YAW
ROLL
PITCH

Figure #10 - Basic Flight Motions

Every airplane consists of common parts. These parts include landing gear, engine, wing, fuselage, fin, horizontal stabilizer, etc. All of these parts are shown in Figure #11.

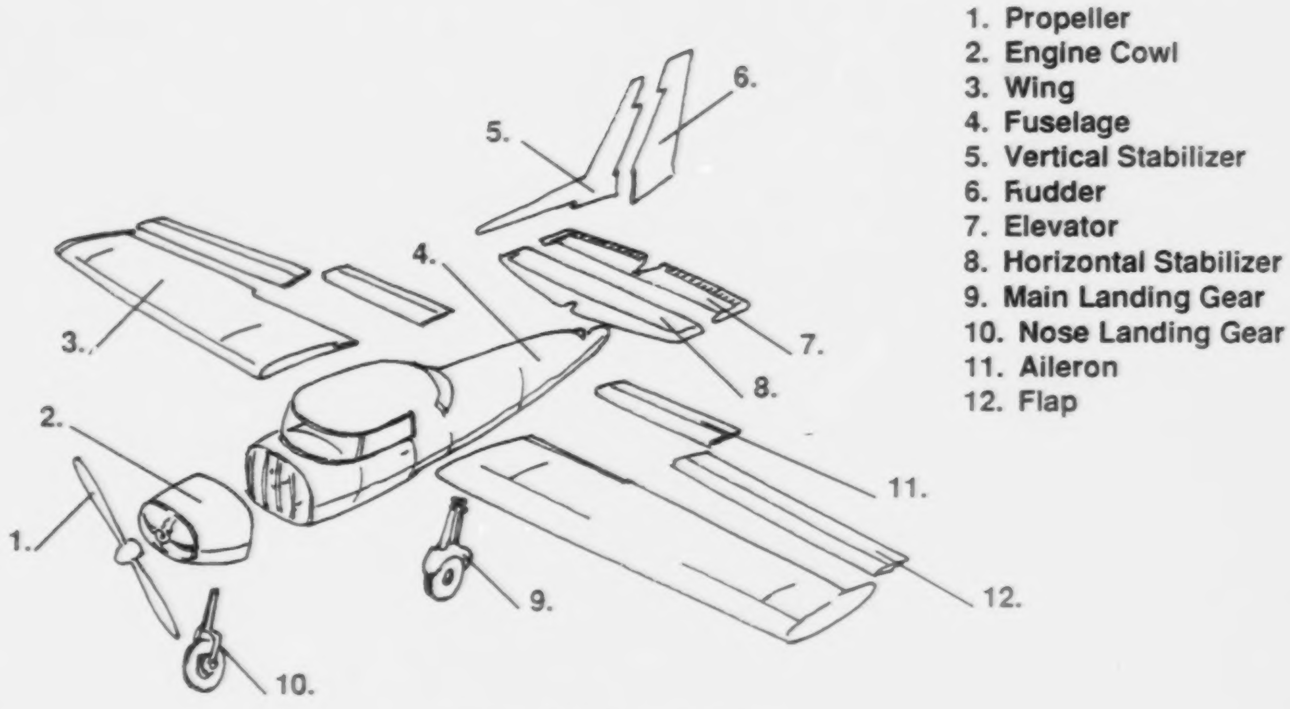
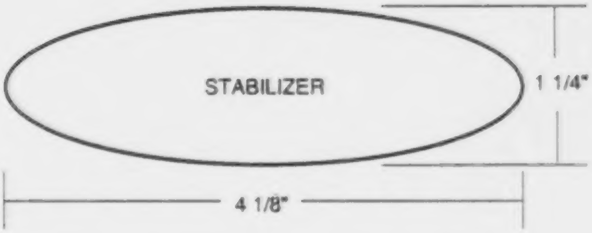
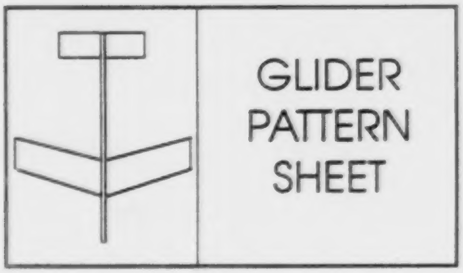

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
1. Propeller
2. Engine Cowl
3. Wing
4. Fuselage
5. Vertical Stabilizer
6. Rudder
7. Elevator
8. Horizontal Stabilizer
9. Main Landing Gear
10. Nose Landing Gear
11. Aileron
12. Flap

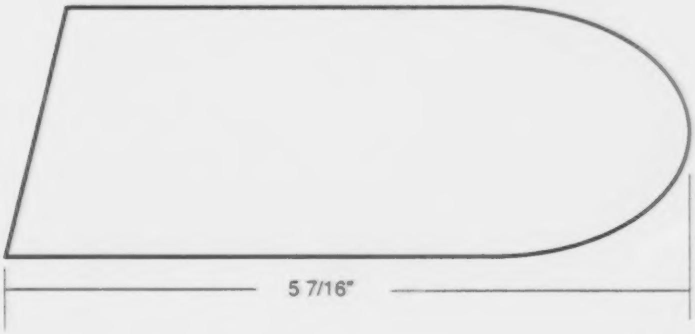
Figure #11 - Airplane Parts

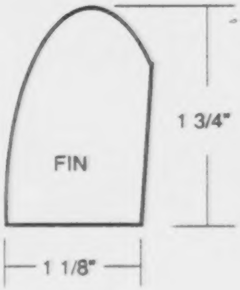
TAM #7 - Handout 2

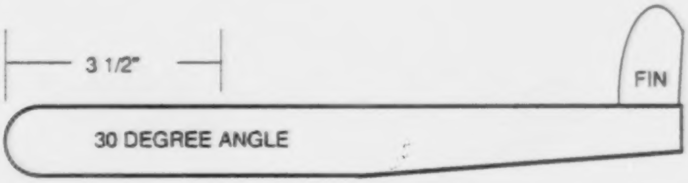
Glider Pattern Sheet


STABILIZER
1 1/4"
4 1/8"


GLIDER
PATTERN
SHEET

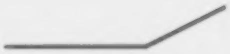





3 1/2"
FIN
30 DEGREE ANGLE

FUSELAGE IS 1/2" x 10 1/2"

WING ANGLE



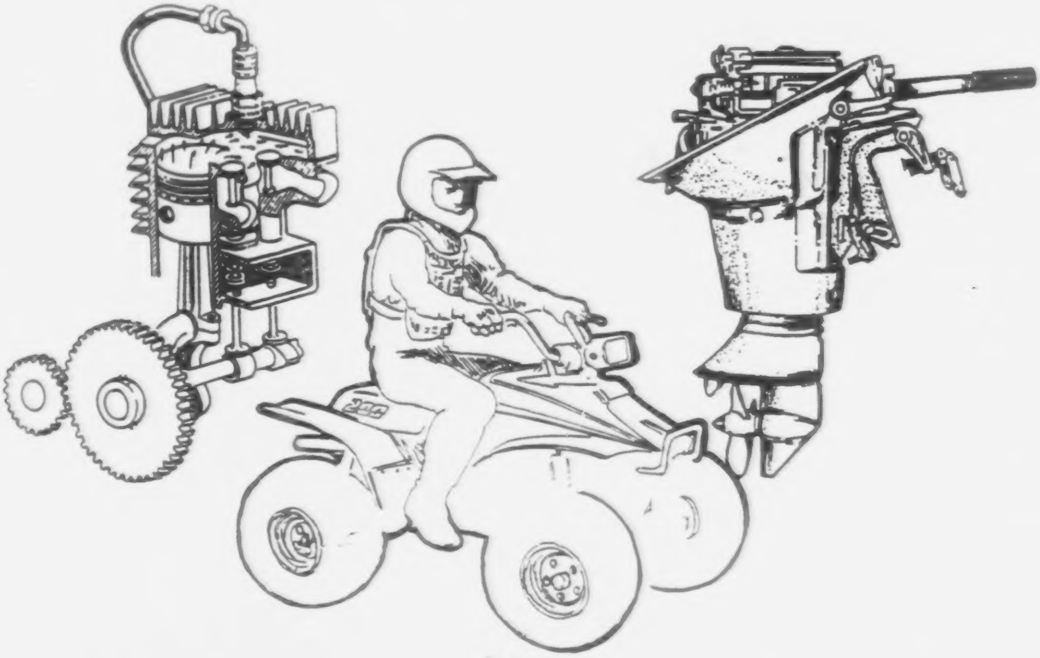
30 DEGREE ANGLE

Course:	Introduction to Energy & Power Technology

Technology Activity Module #8

Internal Combustion: Energy Converters

by: John Sapko



TAM #8: Internal Combustion: Energy Converters
Engine Tune-up & Rebuilding

Instructor Component

Activity Objective: The purpose of this activity is to teach students to identify and classify engines, locate engine specifications, diagnose malfunctions and perform a small gasoline engine tune-up (Activity #1). Students will also learn how to disassemble internal engine parts, inspect and measure parts, reassemble the engine and adjust valves (Activity #2).

Activity Competencies: By completing this TAM, the student will be able to:

1. Identify and classify small gasoline engines.
2. Locate and record original manufactured part dimensions and engine service specifications.
3. Identify major engine parts and orally or in writing describe the operating cycle (sequence) of 2- and 4-stroke cycle engines.
4. Perform an Initial Engine Diagnostic Procedure and identify defective and/or malfunctioning parts or systems.
5. Test and evaluate engine compression.
6. Tune-up a small gasoline engine by adjusting ignition breaker points and ignition coil air gap, replacing and adjusting spark plugs, cleaning air filters and adjusting the carburetor air-fuel mixture.
7. Disassemble the internal parts of a small gasoline engine.
8. Inspect, measure and compare engine parts to manufacturer's specifications.
9. Clean and reassemble internal engine components.
10. Adjust valves and torque engine bolts.

Module Instructions

Introduction:

The activities in the TAM are designed to encourage students to read service and specification manuals, develop problem solving abilities and practice dismantling and reassembling small gasoline engines. The activity sequences include tuning-up, dismantling and rebuilding an engine. Therefore, depending on available tools and equipment, some steps in the activities may be omitted.

Safety Considerations:

Note: Student safety handout requires the instructor's signature _before_ students perform the activities.

- Safety glasses are required at all times when working with engines.
- Parts may break and fly off running engines.
- Loaded springs may pop out during disassembly.
- Take care with mufflers, they may become very hot.
- High voltage electricity may arc from worn spark plug wires.
- Sheet metal parts become ragged and razor sharp.
- Wrenches slip on worn or rounded-off bolts.
- A fire hazard exists from leaking fuel systems.

Needed Materials:

1. **Supplies Required**
   - A. Gasoline (only if engines will be run) - Safety container and storage cabinet required, district or state laws may apply
   - B. Lubricants, assorted engine oils
   - C. Cleaning solvent with storage container (parts cleaner)

2. **Equipment/Machines/Tools**

A. Tune-up Tools	B. Rebuilding Tools
- Compression gauge	- Assorted 3/8" drive sockets
- Flat straight feeler gauge	- Dial indicator
- Spark plug gauge/wire gauge	- Wrenches
- Flywheel puller & holder	- Valve spring compressor
- Micrometer 0-1"	- Piston ring compressor
- Assorted screwdrivers	- Torque wrench
- Spark plug socket/wrench	- Telescoping gauges 1-3"
- Assorted combination box and open end wrenches	- Micrometer's 0-3" adjustable; or 1-2" & 2-3"

3. **Handouts**
   - A. Student component of TAM #8 (Note: Activities for this TAM are based on a Briggs & Stratton engine. The activities could be easily adapted for instruction on engines built by other companies)
   - B. Handout #1: Safety Handout

4. **Instructional Resources**
   - A. Catalogs (construction equipment & materials)
   - B. Books

1. Webster, Jay. (1981). Small engines operation and service. Chicago, IL: American Technical Publishers.
2. Editorial Staff. (1982). Engines compact equipment: Fundamentals of service. Moline, IL: Deere and Company.
3. Pipe, Ted. (1977). Small gasoline engines training manual. Indianapolis, IN: Howard W. Sams & Co.
4. Small Engines Service Manuals. Overland Park, KS: Intertec Publishing Corporation.

5. Briggs & Stratton Operation and Repair Manuals. Milwaukee, WI: Briggs & Stratton Corp.
6. Small engines (Minnesota Curriculum Services Center). Available from Missouri Vocational Resources Center (MVRC). T&I - 47.0606 MN666b
7. Scott, Paul. Small engine repair secondary curriculum guide. (Georgia Department of Education). Available from Missouri Vocational Resources Center (MVRC). T&I - 47.0606 S84

C. Film slides/film/video

1. Inside the Small Engine: Series I and II, Servicing the Small Engine, and Overhaul the Small Gasoline Engine, VHS Videos, CRW Educational Systems, Costa Mesa, California
2. Small Engines, VHS Video, CRW Educational Systems, or Bergwall, Garden City, New York
3. Small Engine Know-How, VHS Video, Career Aids, Chatsworth, CA

Management/Logistics:

1. Related TAMS

This TAM may be used in conjunction with TAM #7, Measuring Power, or as an independent activity.

2. Evaluation/Grading

A. Grading of the TAM may be accomplished by assigning a 30-40% value on test scores and 60-70% on activities. Evaluation of test scores can be handled by assigning a point value to each test item. Evaluation of activities may be accomplished by assigning point values to each major part of the activities.

B. Places for students to record information and the instructor's signature are provided in the activity sheets.

3. Suggested Schedule/Time

The time suggested for this TAM is a minimum of two weeks (one hour per day, five days per week).

Key Instructional Suggestions:

1. Safety

Students should be alerted to the dangers of electrical shock and spark, especially when working around water, gasoline, or flammable solvents. Dangers posed by loose springs, sharp metal edges, and hot mufflers need to be discussed. The primary focus needs to be on the importance of personal protection items such as gloves and safety glasses.

2. Motivation

Allow students to bring in engines from home. (NOTE: This may create a storage problem). Bring in an engine and cut out sections to view the internal parts. Have students mount engine parts on plywood to use as class visual aids and attach student names. If school engines are used for instruction, then a lawn mower clinic could be run where students or faculty bring in their lawn mowers for clean-up and tune-up as a business for profit.

3. **Prerequisite Information**

None. However, this activity module could be combined with a class discussion and/or a question-answer session for greater student understanding. Class presentations covering "How to identify 2- and 4-stroke cycle engines" and "Major engine parts and operating sequence" should be discussed.

4. **Demonstrations**

Due to class time limitations, attempts to limit the length of the TAMs and the difficulty in preparing detailed step-by-step written instructions, the following demonstrations may be added: disassembly and reassembly of a manual starter and float-type carburetor, lapping of valves, installing a piston, measuring crankshaft end-play, and testing ignition coil.

5. **Reinforcement**

The activities contained in this module provide an excellent means for reinforcing basic principles from physics (heat transfer, friction, energy conversion, etc.), chemistry (chemical changes occurring in fuels as a result of the combustion process, incomplete combustion, chemical properties of alternate fuels, etc.), and mathematics (measurement principles). Teachers from these other departments could be invited to talk with the class.

6. **Attitudes**

Some important attitudes can be reinforced in this module. The importance of precise measurement, cleanliness, and attention to detail are easily stressed. As you teach the unit, point out the problems (some of which will cause considerable damage to the engine) that will develop in the engine if the student fails to carefully attend to necessary detail. It is also useful to extend the discussion/application to larger engines and even systems such as nuclear power plants. It is critical that positive safety attitudes be discussed and reinforced. Students may not appreciate or realize the extreme danger involved in working with empty gasoline tanks, physical contact with fumes, and solvents. The need to maintain a clean and safe work environment, and the replacement of tools and equipment should be encouraged.

7. **Remediation/Enrichment**

Remediation: Failure of student to pass written tests or to complete sections of the activities may be handled by allowing study time and the taking of an alternate teacher-prepared test or redoing of the activity.

Enrichment: Permit students that complete the TAM sooner than the rest of the class to work on a different type of engine, such as an automobile engine. Students could also test the efficiency of various tune-up settings and alternative fuels.

8. **Summary & Review**

In this TAM, students have experienced the working conditions and have developed the technical knowledge and skills of a small engine technician.

While they have studied and worked only on a small gasoline engine, this knowledge and these skills are transferrable to other similar energy converters (engines) utilized in transportation systems. The following competencies should be reviewed:

A. How to identify engines.

B. What information is needed and how to locate engine specifications and service information.

C. The cycle of operation of 2- and 4-stroke engines.

D. The purpose of performing diagnostic procedures.

E. The need for accuracy in tightening fasteners, measuring dimensions, and making adjustments.

9. **Review Questions & Answers** (answers in italics)

A. Give several examples of the kinds of engine information that may be needed to locate engine service and manufacturer's specifications.

The name of engine manufacturer, 2- or 4-stroke cycle, horsepower and/or cubic inch displacement, crankshaft operating position, model and/or serial numbers, type and/or specification number, type of fuel system, ignition system and/or starting system.

B. Name the five events that must occur and describe the operating sequence of a 4-stroke cycle engine.

1. *Intake - valve opens, piston moves down, vacuum created, atmosphere pushes air and fuel into the cylinder (stroke number 1).*

2. *Compression - valve closes, piston moves up (stroke number 2), volume reduces, pressure and temperature rises.*

3. *Ignition - electricity created by the magnet passing the coil arcs across the spark plug gap and ignites the air-fuel mixture.*

4. *Power - heat expands gases and increases pressure to push piston down (stroke number 3).*

5. *Exhaust - valve opens, piston moves up (stroke number 4), pushes burned and unburned gases out, sequence begins again.*

C. When performing an engine tune-up, what items (parts) may need cleaning, adjusting, or replacing?

Air filter, spark plugs, breaker points, ignition coil, carburetor, cooling fins.

D. When reassembling the internal parts of an engine, name the parts that must be accurately aligned and explain the need for alignment.

The camshaft and crankshaft sprockets (gears) must be correctly aligned because they govern the opening and closing of the valves. Also, the connecting rod cap, if installed backwards, may damage the crankshaft and connecting rod.

Date: ________ Class: ________ Name: ____________________________

TAM #8 - Small Engine Tune-up and Rebuilding - Pre-test

Instructions: Circle the letter that correctly answers the question.

1. A two-stroke cycle engine can be identified by:
   A. The muffler being located near the cylinder head
   B. A compression stroke for every two crankshaft rotations
   C. The carburetor mounted on the crankcase end
   D. The oil sump and oil filter plug

2. If your engine has a compression release on it, which of the following tests would you perform?
   A. Crankshaft Rotation Test
   B. Crankshaft Rebound Test
   C. Compression Gauge Test
   D. Compressed Air Leakage Test

3. The part of an engine that absorbs the heat and pressure of expanding gases to power the engine is the:
   A. Piston
   B. Crankshaft
   C. Camshaft
   D. Intake valve

4. Which of the following is the correct sequence of events that must occur in order for the engine to function properly?
   A. Power, compression, ignition, exhaust, intake
   B. Ignition, power, exhaust, compression, intake
   C. Intake, compression, ignition, power, exhaust
   D. Exhaust, intake, compression, ignition, power, exhaust

5. Which of the following initial engine diagnostic procedures would you perform first?
   A. Visual inspection and fluid check
   B. Ignition spark test
   C. Fuel test
   D. Compression test

6. Which of the following most likely would not be required to locate service specifications?
   A. Model and/or serial number
   B. Type of fuel and oil required
   C. Number of strokes per cycle
   D. Vertical or horizontal crankshaft

7. Which of the following parts must be disconnected and/or removed before the piston can be removed from the engine?
   - A. Crankshaft
   - B. Camshaft
   - C. Valves
   - D. Connecting rod cap

8. Which of the following measuring devices would you use to precisely measure the amount of crankshaft end-play?
   - A. Micrometer
   - B. Inside caliper
   - C. Ruler
   - D. Dial indicator

9. Which of the following engine parts would most likely be installed last when reassembling these parts?
   - A. Piston
   - B. Cylinder head
   - C. Camshaft
   - D. Valves

10. Which of the following measuring devices would you use to measure valve clearance between the stem and tappet?
    - A. Dial indicator
    - B. Round wire gauge
    - C. Flat feeler gauge
    - D. Micrometer

Date: ________ Class: ________ Name: ____________________________

TAM #8 - Small Engine Tune-up and Rebuilding - Post-test

Instructions: Circle the letter that correctly answers the question.

1. A four-stroke cycle engine can be identified by the fact that:
    - A. Oil is mixed with fuel
    - B. The carburetor is mounted on the crankcase end
    - C. The muffler is located half-way down the cylinder
    - D. There is a compression stroke for every two crankshaft rotations

2. A compression test using a gauge shows a low reading. Oil is then squirted into the cylinder and a retest now shows a higher gauge reading. What caused this?
    - A. Worn piston rings
    - B. Burned valve
    - C. Loose connecting rod
    - D. Leaking head gasket

3. Which of the following permits air and fuel to enter the engine?
    - A. Piston
    - B. Crankshaft
    - C. Intake valve
    - D. Camshaft

4. In a four-stroke cycle engine the piston moves downward in the cylinder during:
    - A. Intake and compression strokes
    - B. Intake and power strokes
    - C. Compression and power strokes
    - D. Compression and exhaust strokes

5. Which of the following diagnostic tests would tell you if the engine is functioning correctly internally?
    - A. Visual inspection
    - B. Fuel test
    - C. Ignition test
    - D. Compression test

6. Which of the following is considered a manufacturer's part specification?
    - A. Breaker point air gap
    - B. Cylinder bore diameter
    - C. Valve tappet clearance
    - D. Carburetor pre-set adjustment

7. Which of the following parts must be removed before the piston can be removed from the engine?
   - A. Crankshaft
   - B. Camshaft
   - C. Cylinder head
   - D. Valves

8. A broken or worn-out compression ring will most likely result in:
   - A. Increased oil consumption
   - B. Decreased oil consumption
   - C. Poor starting and loss of power
   - D. No electricity arcing across the spark plug

9. Which of the following engine parts must be installed first when reassembling the engine?
   - A. Piston and connecting rod
   - B. Crankshaft and camshaft
   - C. Piston rings and piston pin
   - D. Valves and cylinder head

10. Failure to correctly torque the connecting rod bolts may result in:
    - A. Crankshaft knocking
    - B. Leaking head gasket
    - C. Leaking crankcase oil
    - D. Burned exhaust valve

TAM #8: Internal Combustion - Test Keys

TAM #8 - Pre-test answers

1. C   2. B   3. A   4. C   5. A
6. B   7. D   8. D   9. B   10. C

TAM #8 - Post-test Answers

1. D   2. A   3. C   4. B   5. D
6. B   7. C   8. C   9. C   10. A

TAM #8: Internal Combustion: Energy Converters
Engine Tune-up & Rebuilding

Student Component

Introduction:

Think of a funny car at the drag strip. If you think it's quick, think about how fast and how far the engine parts are moving. When you think about it, it's amazing that it doesn't blow up. How do the parts hold together? How does all that precision tuning hold up under all that stress? It's almost magic. Exactly the same principles that go into building and tuning a dragster engine go into building and tuning a small gasoline engine, only on a smaller scale. You've got to be able to figure out what's wrong when it won't run right (or at all). There are all kinds of things that you need to know if you're going to be able to take one apart, repair or customize it, and then get it back together again. This TAM will help you understand how they work. Better, yet, it will give you the ability to make one work.

Competencies: Following the completion of this TAM, you will be able to:

1. Identify and classify small gasoline engines.
2. Locate and record original manufactured part dimensions and engine service specifications.
3. Identify major engine parts and orally or in writing describe the operating cycle (sequence) of 2- and 4-stroke cycle engines.
4. Perform an Initial Engine Diagnostic Procedure and identify defective and/or malfunctioning parts or systems.
5. Test and evaluate engine compression.
6. Tune-up a small gasoline engine by adjusting ignition breaker points and ignition coil air gap, replacing and adjusting spark plugs, cleaning air filters and adjusting the carburetor air-fuel mixture.
7. Disassemble a small gasoline engine's internal parts.
8. Inspect, measure and compare engine parts to manufacturer's specifications.
9. Clean and reassemble internal engine components.
10. Adjust valves and torque engine bolts.

Module Overview:

This module contains the following two activities:

A. Engine Tune-up
B. Engine Rebuilding

Activity Sequence:

A. Participate in your instructor's start-up activities and presentation for this TAM. Follow all instructions, record information, and acquire the instructor's signature before proceeding to the next steps. Read the safety handout before proceeding.

B. Complete the pre-test given by the instructor.

D. Read, review and refer to the textbook readings related to engine identification and tune-up.

E. Complete Activity #1 and record requested information.

F. Read, review and refer to textbook reading related to engine rebuilding.

G. Complete Activity #2 and record requested information.

H. Turn to the review and summary section of this module.

I. Complete the post-test given by your instructor and turn in your module for grading. Ask the instructor for the next TAM.

Key Information:

1. **Class Presentations**
    - How to identify 2- and 4-stroke cycle engines
    - Major engine parts and operating cycle (sequence)

2. **Demonstrations - depending on available time, tools, or equipment**
    - Disassembly and reassembly of rope rewind type starter
    - Disassembly and reassembly of a carburetor
    - Valve face and seat lapping
    - Ignition coil and condenser testing
    - Installing a piston

3. **Safety - major concerns**
    - Electric shock
    - Loose springs
    - Cuts on sharp metal edges
    - Burns on hot mufflers
    - Ignition of leaking gasoline

4. **Personal Activity**
    - Thoroughly read through the activity steps prior to attempting the activities
    - Sign out a library or laboratory textbook and read the related sections at home.

Glossary:

1. **Air Cleaner** -- Removes dirt particles from the air that is entering the engine.
2. **Bearings** -- Provides a surface on which moving parts may rotate with a minimum amount of wear.
3. **Block/Cylinder/Head** -- The block houses the moving parts of an engine. The cylinder is the hollow cylindrical portion of the block in which the piston moves and the head is the covering over the cylinder where the fuel-air mixture is compressed.
4. **Breaker Points** -- A switching device for connecting and disconnecting an electrical circuit.
5. **Camshaft** -- A metal shaft with eccentric lobes which are caused to rotate by the crankshaft and camshaft gears. Its purpose is to open and close the valves at the proper time.
6. **Camshaft Gear** -- A metal disc with teeth that mesh with the crankshaft gear and used to time the opening and closing of the valves.
7. **Carburetor** -- Mixes the proper ratio of fuel with the air that is being forced into the engine.
8. **Coil** -- Contains an iron core with a heavy and a thin wire wrapped around it.
9. **Condenser** -- An area in which electrical charges can be stored.
10. **Connecting Rod** -- Links the piston to the crankshaft.
11. **Crankcase** -- A container that holds oil for lubricating the moving parts.
12. **Crankshaft** -- A revolving metal shaft with an off-set section, where the connecting rod is attached.
13. **Crankshaft Gear** -- A metal disc with teeth, attached to the crankshaft for the purpose of timing the opening of the valves with the rotation of the crankshaft.
14. **Dipper or Slinger** -- Attached to either the connecting rod or camshaft and splashes oil around inside the crankcase to lubricate the moving parts.
15. **Flywheel** -- A metal wheel attached to the crankshaft containing magnets and metal fins. Provides momentum to keep the engine revolving and blows air around the engine to cool it.
16. **Flywheel Key** -- Times the rotation of the flywheel magnets with opening and closing of the breaker points.
17. **Governor** -- Automatically adjusts the quantity of air and fuel from the carburetor during operation of the engine.
18. **Magneto** -- Provides the electrical charge for igniting the fuel-air mixture.
19. **Permanent Magnets** -- Located in the flywheel and used to create a magnetic field to aid in producing electricity.
20. **Piston & Rings** -- The piston is a metal casting that slides up and down in the cylinder and absorbs the force exerted by the burning fuel-air mixture. The rings occupy grooves in the piston for sealing the compression area and controlling oil losses.
21. **Recoil Starter** -- Provides the necessary momentum to start the engine by moving the parts through the operating sequence.
22. **Spark Plug** -- Provides a gap across which an electrical charge must jump to ignite the fuel-air mixture.
23. **Valves** -- Provides an opening through which fuel-air mixture can enter the engine combustion chamber to be burned or to exhaust burned gases from the engine.
24. **Wrist Pin** -- A metal shaft that connects the piston to the connecting rod.

Needed Materials:

1. **Supplies Required**
   - A. Gasoline (only if engines will be run) - Safety container and storage cabinet required, district or state laws may apply (instructor permission required).
   - B. Lubricants, assorted engine oils.
   - C. Cleaning solvent with storage container (parts cleaner).

2. **Equipment**

   A. TUNE-UP TOOLS

   - Compression gauge
   - Flat straight feeler gauge
   - Spark plug gauge/wire gauge
   - Flywheel puller & holder
   - Micrometer 0-1"
   - Assorted screwdrivers
   - Spark plug socket/wrench
   - Assorted combination box and open end wrenches

   B. ENGINE REBUILDING TOOLS

   - Assorted 3/8" drive sockets
   - Dial indicator
   - Wrenches
   - Valve spring compressor
   - Piston ring compressor
   - Torque wrench
   - Telescoping gauges 1-3"
   - Micrometer's 0-3" adjustable; or 1-2" & 2-3"

3. **Handouts/Instructional Resources**
   - A. Safety Handout: Handout #1. Read before proceeding. (Instructor signature required before performing activities)

TAM #8: Internal Combustion: Energy Converters
Engine Tune-up & Rebuilding

Activity #1: Engine Tune-Up - Plan of Procedure

1. Engine Identification Procedure - Directions: Locate and record the following information for your engine. Some or all of this may be necessary to locate the manufacturing servicing and parts specifications for a particular engine (Figure #1).

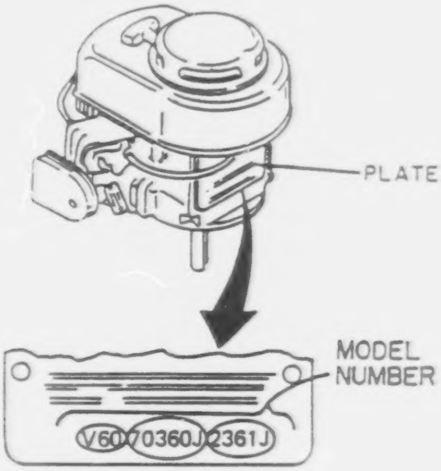


Figure #1 - Engine Data Placement

A. Major Engine Utilization Category and Type of Equipment

- Lawn and/or Garden ______________________________
  (Specific type of equipment)
- Transportation and/or Recreation ______________________
  (Specific type of equipment)
- Industrial and/or Commercial Application __________________
  (Specific type of equipment)
- Equipment Manufacturer's Name ______________________

B. Engine Classification and Identification

- Reciprocating Piston ☐ Rotating Rotor ☐
- 4-Stroke Cycle ☐ 2-Stroke Cycle ☐
- Vertical Crankshaft ☐ Horizontal Crankshaft ☐ Multiple Crankshaft ☐

C. Engine Nameplate Information

- Engine Manufacturer's Name ______________________
- Engine Model Number ___________________________
- Engine Serial Number ___________________________

- Engine Type Number ______________________________
- Engine Specification Number ______________________________
- Engine Horsepower ______________________________
- Cubic Inch or Centimeter Displacement ____________________

D. Special Engine Features and Accessories - Refer to textbooks or Service Manual for differences.

- Type of Carburetor: Float ☐ Diaphragm ☐ Suction Lift ☐
- Type of Fuel Pump: Mechanical ☐ Differential Pressure ☐ Electrical ☐
- Type of Air Filter: Oil Bath ☐ Oiled Filter ☐ Dry ☐
- Type of Governor: Pneumatic (Air Vane) ☐ Mechanical (Centrifugal) ☐
- Type of Ignition: Magneto ☐ Battery ☐
- Type of Starter: Rope-Wind ☐ Rope-Rewind ☐ Wind-up ☐ Electric ☐
- Type of Crankcase Breather: Reed Valve ☐ Floating Disk ☐ Check Valve ☐

2. Locate Manufacturer and Service Specifications - DIRECTIONS: Using your Engine Identification Information Sheet and the Servicing Manuals, locate and record the following for your engine:

A. Manufacturing Specifications when Engine was New

- Cylinder Diameter = ... ____________
- Intake Valve Tappet Clearance = ... ____________
- Exhaust Valve Tappet Clearance = ... ____________
- Piston Compression Ring End-Gap Clearance = .. ____________
- Piston Oil Ring End-Gap Clearance = ... ____________

B. Engine Service Specifications

- Spark Plug Gap = ... ____________
- Breaker Point Gap = ... ____________
- Permissible Amount of Cylinder Wear = ... ____________
- Magneto Armature Air Gap Clearance = ... ____________
- Cylinder Head Bolt Torque = ... ____________
- Connecting Rod Bolt Torque = ... ____________

3. Perform the following Initial Engine Diagnostic Procedures:

A. Perform Visual Inspection and Check (✓) the Results

	CONDITION	
	Yes	No
• Oil leaks	____	____
• Water leaks	____	____
• Fuel leaks	____	____
• Exhaust leaks or restrictions	____	____
• Corroded, frayed, broken or disconnected wiring	____	____
• Broken, loose or missing bolts	____	____
• Loose/broken engine mounts/housing	____	____
• Vacuum leaks, broken or disconnected hoses, loose intake manifold or carburetor bolts	____	____

B. Initial Test Procedures - Check (✓) Results

CONDITION

- Spark Test (Figure #2)
  1. Disconnect the spark plug wire
  2. Remove the spark plug
  3. Reattach the spark plug wire to the spark plug
  4. Clip or hold the metal shell of the spark plug against the cylinder head
  5. Crank the engine and observe the spark
     (a) Spark is bright blue - ignition system is good ____
     (b) Spark is orange - engine is not rotating fast enough to generate a good spark, or some part in the ignition system is defective ____
     (c) No spark - defective spark plug or ignition parts; disconnect plug wire and hold the end of the wire 1/4 inch from engine metal and crank-if a spark appears now, replace the spark plug; if there is still no spark, dismantle and test all ignition parts ____

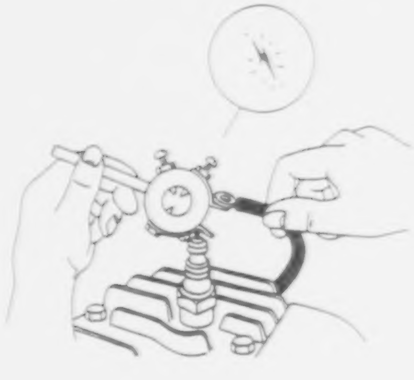


Figure #2 - Spark Test

- Fuel Test
  1. Disconnect spark plug wire and ground (attach) it to the engine block
  2. Remove spark plug

3. Close carburetor choke
4. Hold your thumb over spark plug hole and crank engine (repeat several times)
   (1) Thumb gets wet with gasoline - fuel system is good .... _____
   (2) Thumb does not get wet with gasoline - check fuel system.............................. _____

4. Test and Evaluate Engine Compression - Perform as many of these tests as possible and record the results.

A. Crankshaft Rotation Compression Test

- Disconnect the spark plug wire and attach it to the engine block to prevent the engine from starting.
- Turn the flywheel by hand until it comes up to compression stroke. With a 4-STROKE ENGINE, you should notice a definite resistance at every second revolution of the crankshaft.
- Record the results for this test: **Compression: Good __ Poor __**

B. Crankshaft Rebound Compression Test - for engines with compression release on the exhaust valve (Figure #3).

- Disconnect the spark plug wire and attach it to the engine block to prevent the engine from starting.
- Give the flywheel a quick twist by hand in the opposite direction of normal rotation.

NOTE: If the compression is good, the flywheel will spring back from the force of the compressed air in the cylinder.
If the compression is poor, there will be little or no resistance to the flywheel turning; nor will the flywheel spring back.

- Record the results for this test: **Compression: Good __ Poor __**

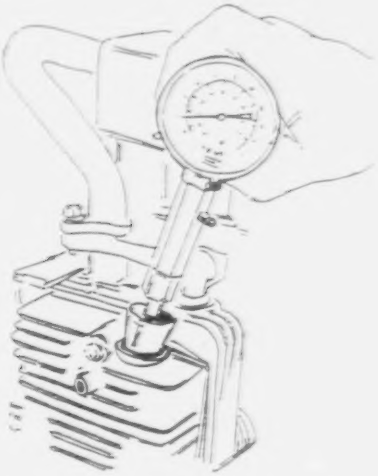


Figure #3 - Compression Check

C. Compression Gauge Compression Test

- Remove the spark plug and attach the spark plug wire to the engine block.
- Insert a compression gauge in the spark plug hole.
- Turn the engine at least 6 to 8 revolutions at cranking speed.
- Observe and record the compression gauge reading.

Gauge Reading ___________

NOTE: Compare this reading with that given in the manufacturer's manual. On most engines, a reading of 30 pounds per square inch is satisfactory. If the compression is less than 30 pounds per square inch, proceed with the following steps:

(1) Remove the compression gauge and place a tablespoon of oil in the cylinder.
(2) Replace the compression gauge and crank the engine 6 to 8 revolutions.
(3) Observe the compression gauge reading and record the results.

Gauge Reading ___________

NOTE: A higher compression gauge reading usually indicates damaged rings. A low compression gauge reading usually indicates damaged valves, cylinder, or head gasket.

Compression: Good ___ Poor ___

5. Check and Adjust the Ignition System as follows:

A. Remove Spark Plug - Visually inspect and adjust

- **Visually inspect and check (✓) the condition observed**

1. Normal Condition ___
   a. Porcelain insulator nose is brown or tan in color
   b. No cracks or brown streaks on upper portion of porcelain
   c. Slight rounding off of center electrode

2. Wet (oily) ___
   a. Defective spark plug
   b. Defective piston rings
   c. Worn intake valve guide

3. Wet (gasoline) ___
   a. Choke stuck closed
   b. Clogged air filter
   c. Improper fuel/air mixture
   d. Defective spark plug

4. Dry black carbon-either hard or fluffy ___
   a. Improper fuel/air ratio
   b. Air filter clogged
   c. Incorrect spark plug

- Check spark plug air gap using a wire feeler gauge. **Correct gap is __________**
- Adjust plug air gap by bending ground electrode up-or-down to achieve correct setting.
- Have your instructor check and sign your activity sheet.

Instructor ________________________

B. Check and/or Adjust Ignition Coil Air Gap as Follows

- Remove flywheel cover bolts and cover assembly.
- Using a flat feeler gauge, check the air gap between the ignition coil armature legs and the flywheel surface.

Correct air gap is ____________________________

- If necessary, adjust the air gap by loosening the coil retaining bolts and sliding the coil toward or away from the flywheel until the correct setting is achieved, then retighten the coil bolts.

- Have your instructor check and sign your work.

Instructor ______________________

C. Check, Replace or Adjust Breaker Points as follows (Figure #4):

- Remove flywheel bolt/nut/drive unit by holding the flywheel and rotating the bolt/nut/drive counterclockwise.
- Remove flywheel by : (see instructor for correct method)
  - a. Using the correct flywheel puller; or,
  - b. Driving a wooden wedge between the flywheel and engine block; or,
  - b. Lifting up on flywheel and tapping lightly on shaft with a plastic or brass hammer
- Remove breaker point cover, retaining bolts and cover.
- Inspect breaker points for burns, metal transfer, and misalignment - replace damaged points and condenser.
- Rotate crankshaft until breaker points open, check setting using flat feeler gauge and loosen and adjust gap as necessary.

Correct gap is ______________________

- Have instructor check and sign your work.

Instructor ______________________

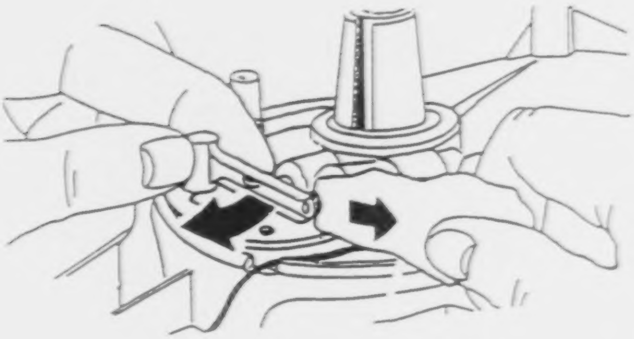


Figure #4 - Point Adjustment

- Reassemble point cover, flywheel, and flywheel cover in reverse order of disassembly Check and replace flywheel key as necessary.
- Hold a screwdriver handle with finger tips, bring the metal tip near flywheel magnets-it should attract tip from 1/2" away.

6. Check, Clean and/or Adjust Fuel System as follows

   A. Remove air filter and clean or replace filter. Paper filters are generally replaced; sponge/foam type filters are cleaned with soap and water, dried, and re-oiled; oil-bath types have the cup of oil dumped out, cleaned and refilled with oil to the correct level.

   B. Check the operation of the choke (Figure #5).

   - Manual types - pull or operate the cable/lever and the choke plate/valves should open and close.
   - Automatic types - when the engine is not running, the choke plate/valve is generally closed-push it open, and a spring should reclose it.
   - Clean or repair as necessary.

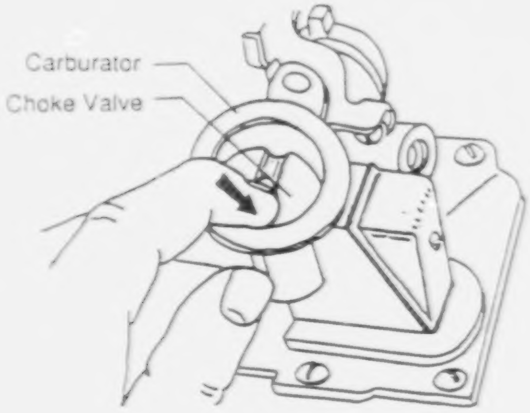


Figure #5 - Choke Check

C. Check fuel, fuel tank and cap.

- Smell fuel - stale gasoline has a foul smell.
- Check fuel tank for leaks, rust inside, or loose mounting bolts.
- Check fuel tank cap gasket and air vent, clean and/or replace as necessary.

D. Check and adjust carburetor fuel/air mixture as follows:

- Always check your service manual for pre-starting adjustments.
  Number of mixture adjustment screw turns ________________________.
  (NOTE: They may range from 1-1/2 to 2-1/2 turns out).
- Locate the mixture adjust screw (see service manual).
- Slowly rotate the mixture screw in until it stops.
  (NOTE: If screwed in tight the tip may be damaged).
- Observe the screw slot and rotate the screw back out the number of turns recorded in step 1. Have your instructor witness and sign your work.

Instructor ____________________________

E. Ask the instructor for permission to start the engine and fine tune the carburetor. NOTE: Unless exhaust ventilation and engine mounting is available, this should not be attempted inside the laboratory.

- Fine carburetor adjustment is accomplished with the engine running by slowly turning the mixture screw in until engine speed drops, then out until speed drops again, then back in until it smooths out. When correctly adjusted, opening the throttle will smoothly speed up the engine; or,
- If a tachometer is available, note the revolutions-per-minute (RPM) of the engine and slowly turn the mixture adjusting screw in until the RPM begins to drop. Then, slowly turn the mixture screw out. The RPM should increase and then decrease again as you continue to turn the screw out. When the RPM begins to decrease this time, stop and slowly turn the screw in until the highest reading is obtained. (Repeat until the engine runs properly).

TAM #8: Internal Combustion: Energy Converters
Engine Tune-up & Rebuilding

Activity #2: Engine Rebuilding - Plan of Procedure

DIRECTIONS: Follow the step-by-step procedure to disassemble and reassemble the engine. Record requested information and obtain the instructor's signature where applicable. NOTE: It may be necessary to refer to your engine's service manual for specific detailed procedures. Always check the manufacturer's specifications for all measurements. Refer to Figure #6 for an overview of the engine's components.

1. Measure and record crankshaft end-play as follows:
   - A. Obtain and mount a dial indicator on the engine block with the pointer touching the end of the crankshaft. Push the crankshaft in as far as it will go, rotate the dial-indicator to zero (0), pull the crankshaft back out, and record reading; or,
   - B. Pull the crankshaft out as far as it will go, touch the end of the crankshaft against a solid straight surface, C-clamp the engine to the bench top, and push the crankshaft back in. Determine which straight feeler gauge will fit into the air gap and record its size.

     Actual End-gap is _________ Manufacturer's Spec. is ____________
   - C. Have the instructor check your results and sign your module.

     Instructor signature ______________________________
2. Remove the starter housing and flywheel as described in Activity #1 - Tune-up or as described in your service manual.
3. Remove the air filter and disconnect carburetor controls and linkages. NOTE: Do not bend any straight links. Instead, unbolt the carburetor, intake manifold or fuel tank and rotate it to disconnect the links. Ask the instructor how to store or dispose of fuels.
4. Disconnect the spark plug wire and unbolt all metal covers that go over the cylinder head. NOTE: If any head bolts are removed, draw a picture of the head bolt locations, measure the bolt length and record it on your drawing. Proceed to removing all head bolts.
5. Lift off the cylinder head, clean and inspect all surfaces for cracks, and check the head for warping by placing a straight-edge across the surfaces. NOTE: If a .003" feeler gauge fits under the straight edge, then the head needs to be polished flat or replaced.

   Cylinder head condition: good ☐ bad ☐

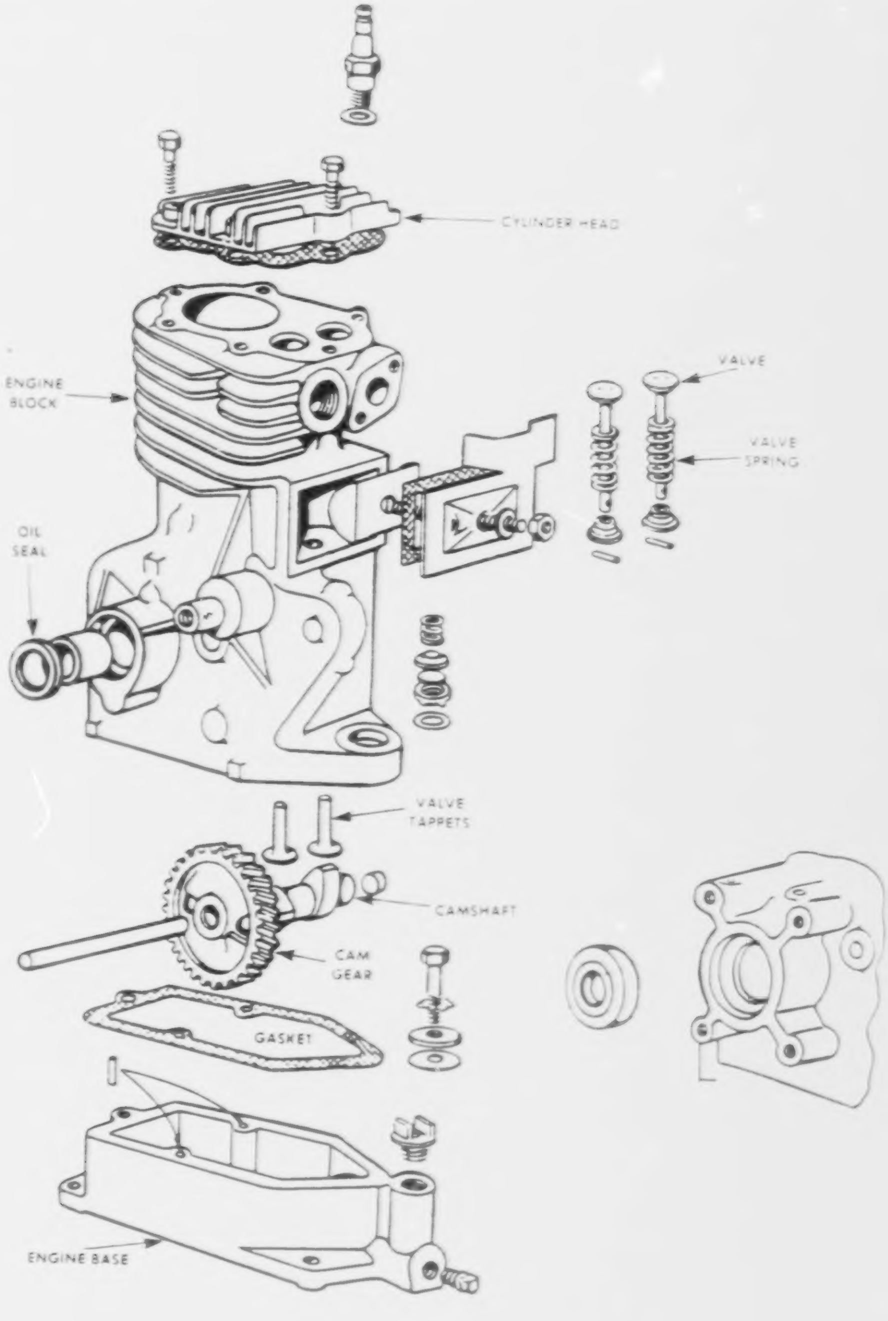

CYLINDER HEAD
ENGINE BLOCK
VALVE
VALVE SPRING
OIL SEAL
VALVE TAPPETS
CAMSHAFT
CAM GEAR
GASKET
ENGINE BASE

Figure #6 - Engine Component Overview

6. Remove the valve access well cover and inspect the gaskets and crankcase ventilation valve. Remove and clean the filter. Check your service manual for crankcase valve measurements.

7. Compress the valve springs and remove the valve spring retainer, then lift out the valves and inspect the valve seat and valve face for carbon build-up, cracks, warping or bending, and face to seat contact. Clean, repair or replace as necessary.

8. If a small hole gauge and micrometer are available, measure and record the valve stem diameter and the valve guide diameter.

	Measure Stem Diameter	Measure Guide Diameter	Difference Between Stem & Guide
Intake Valve			
Exhaust Valve			

(NOTE: Intake valve stem to guide clearance is typically between .001 - .004. Exhaust valve .002 - .005)

9. Drain the engine oil into an appropriate storage container. Ask instructor.

10. Unbolt and remove the crankcase/side cover from the engine to expose the internal parts. NOTE: Place the engine in a position so that the cover can be lifted vertically.

11. Observe the condition and location of all internal parts, as all parts must be returned to their correct location. Locate the timing marks on the crankshaft and camshaft gears, rotate the shafts until the marks align, and carefully lift out the oil slinger and camshaft.

12. Slide out the valve tappets/lifters, wrap tape around them and mark which hole they came from. Inspect the top and bottom-both should be fairly flat.

13. Rotate the crankshaft until the piston is at the bottom of the cylinder. Put your hand into the cylinder and drag your fingernail up the side. If your nail catches on a ridge at the top, the ridge may need removal before the piston will come out. Have your instructor check yours and sign your module here.

Instructor signature ______________________________

14. Using a straight bladed screwdriver and hammer or pliers, bend back the connecting rod bolt locks.

15. Using a scratch awl or similar tool, draw a line across the connecting rod to rod cap mating surfaces. When reassembling these parts, the line should be facing you.

16. Remove the connecting rod bolts, lift off the rod cap and slowly push the piston up and out of the cylinder. NOTE: When the rings have cleared the cylinder, the piston may pop out, so place your hand over the piston and catch it.

17. Slowly withdraw the crankshaft from the engine and clean and inspect all parts. (Caution: the breaker point plunger on the ignition side of the engine may need to be removed before the crankshaft will come out.)

Instructor signature ______________________

(NOTE: Ask your instructor if the necessary tools and equipment are available to complete steps 18 through 24. If not, proceed to step 25 and begin the reassembly. See Figure 3.)

18. Place the crankshaft in a set of "V" blocks, put the tip of the dial indicator against the main bearing support surface, zero (0) the gauge and rotate the crankshaft. Repeat on the other surface. NOTE: A straight shaft will typically vary less than .001".

Check manufacturer's specifications = ____________________
Measure crankshaft out-of-round = ____________________

19. Using either a telescoping gauge and outside micrometer or an inside micrometer, measure the cylinder diameter in 2 places down the wall, turn your gauge 90 degrees and make 2 more measurements. Record your results.

	Cylinder Diameter Measurement	90 Degree Cylinder Diameter Meas.	Difference Between Meas.	Manufacturer's Cylinder Dia.New
Top				
Bottom				

(NOTE: Permitted cylinder out-of-round typically ranges from .001" to .0025". Check manufacturer's specifications. Also, cylinder taper, top-to-bottom, should not exceed .001".)

20. Using a flat feeler gauge, measure the gap between the side of the piston rings and the piston grooves in which the rings are located. Locate and record the manufacturer's specifications. See Figure #7 below.

	Side Clearance	Manufacturer's Specification	Clearance - Good or Bad?
Top Ring			
Middle Ring			
Bottom Ring			

(NOTE: Typical side clearances range from .002" to .007")

21. Carefully remove the piston rings, either by hand or with a piston ring remover. Look carefully at the ends of the rings and mark down which rings fits in which groove. Typical ring ends:

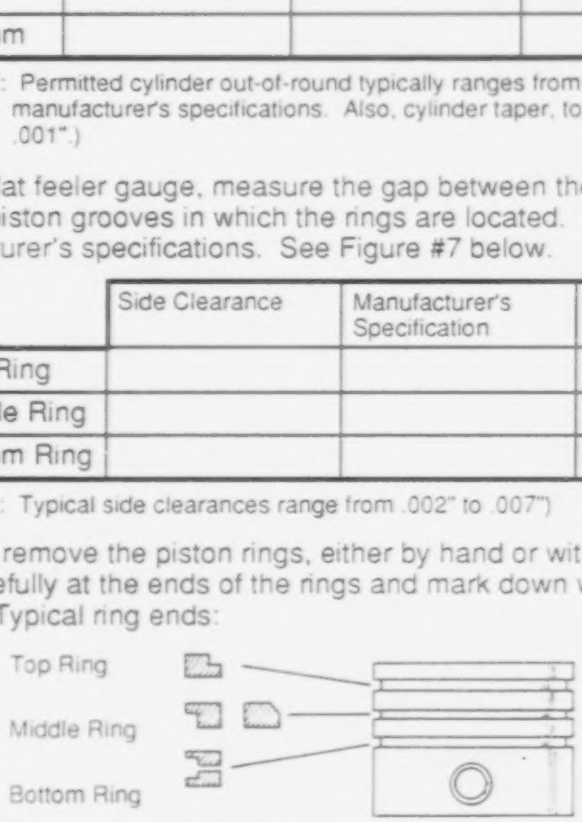


Figure #7 - Piston Ring Clearance

22. Slightly compress the rings one at a time and place them into the cylinder. Invert the piston and push the ring to mid-point, remove the piston and measure and record the end gaps. Repeat for each ring and record.

	End Gap Measurement	Manufacturer's Specification	Good or Bad?
TOP RING			
MID RING			
BOT RING			

(NOTE: Typical maximum permitted ring end gap .040")

23. Measure and record the piston to cylinder clearance by inverting the piston and pushing it into the cylinder. Slide a flat feeler gauge between the piston and cylinder wall. The correct gauge will drag slightly. Record your measurement and compare with manufacturer's specification.

Check manufacturer's specifications = ______________________

Measure crankshaft out-of-round = ______________________

24. Clean and inspect all parts for carbon build-up and cracks. Repair or replace as necessary.

25. Place the new or good used piston rings back into the correct piston grooves (stagger the end gaps 90 degrees) and lubricate the rings, piston and cylinder walls.

26. Place a piston ring compressor over the rings (notches toward connecting rod) and tighten the compressor.

27. Lubricate the crankshaft main bearing journal and correctly reinsert it into the block. Rotate connecting rod journal to lowest piston position.

28. Slowly lower the piston into the cylinder with the alignment mark facing in the correct direction and tap lightly on the ring compressor to seal it against the block. Hold the ring compressor with one hand and tap the piston into the cylinder using the wooden end of a hammer.

29. Pull the piston down and place the connecting rod around the crankshaft. Lubricate the rod cap, align the marks, tighten and torque the bolts, and bend the locking tabs over the bolts.

Instructor's Signature: ______________________

30. Reinstall the tappets in the correct holes.

31. Clean and inspect camshaft. Measure and record the following.

Camshaft Parts	Meas. Size	Manu. Size	Difference Between Manu. & Measurement	Measure Housing Holes	Subtract Camshaft Diameter from Housing
Cam Gear Journal					
Shaft End Journal					
Intake Lobe					
Exhaust Lobe					

(NOTE: Typical shaft journal to housing clearance should not exceed .003")

32. Install camshaft into housing and align timing marks.

33. Reinstall oil slinger.

34. Refer to activity step #1, crankshaft end-play. If measured end-play is greater than manufacturer's specified end-play, then a thinner crankcase/side cover gasket must be installed; if the measured end-play is less than the manufacturer specifies, then add a thicker gasket.

35. Install the gasket and crankcase/side cover and torque the bolts to the correct setting.

36. Refer to activity step #1, remeasure crankshaft end-play and record results here.
Crankshaft end-play is __________________________.

NOTE: If end-play is not within specifications, repeat steps 34 through 36.

37. Place intake and exhaust valves into their valve guides and rotate the crankshaft until the piston is at the top and both valves remain closed with face-to-seat contact.

38. Locate and record the intake and exhaust stem to tappet clearance.

	Manufacturer's Specification	Actual Measured Clearance
Intake Valve Clearance		
Exhaust Valve Clearance		

39. Select the specified manufacturer flat feeler gauge, push the valve down with your thumb and measure the stem to tappet clearance through the access-well opening. The gauge should slide in and out with minimum effort. (NOTE: If a thinner gauge than specified must be used, then subtract the thinner size from the manufacturer specified size and grind that amount from the tip of the valve stem and remeasure). Have your instructor confirm your results and demonstrate valve stem grinding before proceeding.

40. Compress and install valve springs, slide the valve into guide, install spring retainers, and release valve spring. Repeat on other valve.

41. Replace access-well gasket and cover.
42. Install head gasket and head, refer to your bolt pattern drawing, install and torque bolts. **Record head bolt torque here** ______________________________.
43. Replace flywheel, sheet metal covers, fuel system and starter housing in reverse order of disassembly.
44. Have the instructor check and sign your work.

Instructor signature ______________________________

45. Refer back to Activity Sequence.

TAM #8 - Summary

1. **Review & Summary Activities**
   - A. Review the textbook related readings or read a different textbook.
   - B. Carefully reread the competencies at the beginning of this module and discuss with your instructor any of them that you are still not sure you are capable of doing.
   - C. Look up the answers to the pre-test questions that you missed.

2. **Review Questions -- Test yourself!**
   - A. Name at least 3 ways you can identify a 2-stroke cycle engine.
   - B. Name at least 3 types of information you may need to locate service specifications.
   - C. Describe the operating sequence of a 4-stroke cycle engine.
   - D. Describe the steps in performing a tune-up.

TAM #8 - Post-assessment

Instructions:

Check all your work in the activity section and ask the instructor for the Post-test. Turn in your module for grading.

TAM #8 - Handout 1

Safety Handout

General Responsibilities Required of All Students

A. Safety:

1. Observe all laboratory safety rules and precautions while working and conducting experiments.
2. Wear eye protection at all times while working and conducting experiments.
3. Do not remove spark plug wire and hold the end while cranking the engine, or you may get a severe electrical shock.
4. Do not touch mufflers or exhaust pipe on engines that have been running, or you may receive a severe burn.
5. Look for sharp edges on sheet metal parts. Serious injury from razor sharp edges may be encountered.
6. Locate laboratory fire extinguishers prior to conducting experiments and relocate to a stand-by position in the event of perceived fire hazards.
7. Report all injuries immediately to the instructor, regardless of the perceived severity.
8. Each student is responsible for his/her own safety and the safety of their fellow students and must conduct their laboratory activities in an appropriate manner.

B. Clean-up:

1. Each student is responsible for the safe handling and clean-up of tools and equipment utilized in conducting laboratory experiments.
2. Each student is responsible for returning laboratory tools and equipment to their prescribed location when no longer being utilized.
3. Each student is responsible for cleaning up the vicinity in which they conducted their experiments.
4. All students will assist in maintaining the laboratory as a safe and clean environment and assist the instructor when required.

C. Instructor's Signature

The instructor's signature is required before beginning the activities -- be prepared to answer safety related questions.

____

(Instructor Signature)

Course:	Introduction to Energy & Power Technology

Technology Activity Module #9

Fundamentals of Fluid Power

by: Yusuf Al-Hassan

VALVE KIT
PLUMBING
TRAINING AIDS
OIL LEVEL

TAM #9: Fundamentals of Fluid Power

Instructor Component

Activity Objectives: The purpose of this activity is to help students explore the use of pneumatics and hydraulics as they apply to fluid power processes. Student activities focus on basic circuitry and the differences between pneumatics and hydraulics.

Activity Competencies: By completing this TAM, the student will be able to:

1. Describe the characteristics and advantages/disadvantages of two major types of power transmission system: pneumatics, hydraulic.
2. Develop an operational definition and concept of power systems.
3. Define the basic terms commonly used in power systems.
5. Describe the types of power systems used in our society.
6. Employ a systematic design process to produce a power transmission system that meets the assigned design specifications.
7. Describe the applications of pneumatics in a technological society.
8. Describe the applications of hydraulics in a technological society.
9. Construct fluid power systems utilizing typical components.
10. Manipulate common test instruments to analyze fluid power circuits.

Module Instructions

Introduction:

This activity is designed to have students explore the principles and use of pneumatics and hydraulics for fluid power technology. It is recommended that this exciting activity be integrated with ongoing classroom presentations of fundamentals of fluid power technology. The student activities should include safety instructions, demonstrations of fluid power fundamentals, processes, a pre-test, and a post-test.

Safety Considerations:

Safety practices in this TAM are general in nature. They should be observed when dealing with all materials and equipment.

Needed Materials:

1. **Supplies Required**
    - A. Oil
    - B. Cylinder
    - C. Load Plate

D. Weight set: 1 lb., 5 lb., 10 lb., 20 lb.
E. Syringes
F. Plastic tubing
G. Plywood for mounting power steering demonstration unit

2. **Equipment/Machines/Tools**
   A. Hydraulics/pneumatics trainer, complete with cylinders
   B. Fractional horsepower motor
   C. Power steering pump
   D. Power steering actuator (rack and pinion type)
   E. Power steering control valve
   F. Air compressor
   G. Air hose
   H. Ruler
   I. Pressure gauges

3. **Handouts**
   A. Student component of TAM #9
   B. Handout #1: Advantages & Basic Components of Fluid Power Systems
   C. Handout #2: ANSI Symbols

4. **Instructional Resources**
   A. Books
      1. ______. (1968). Fluid power instructor's manual (pp. 7-159). Indianapolis, IN: Howard W. Sams & Co., Inc.
      2. Bohn, R.C., Fales, J., MacDonald, A.J., & Kuetemeyer, V.F. (1986). Energy, power and transportation technology (pp. 89-115). Peoria, IL, Bennett & McKnight Publishing Company. ISBN 0-02-675400-2
      3. Esposito, A. (1980). Fluid power with applications (pp. 1-31, 62-90, 114-136, 219-332 & 390-418). Englewood Cliffs, NJ: Prentice-Hall, Inc. ISBN 0-13-322701-4
      4. Patient, P., Pickup, R. & Powel, N. (1985). Modular courses in technology: Pneumatics (pp. 5-146). London, UK: Oliver & Boyd. ISBN 0-05-003535-5
      5. Pease, D.A. & Pipenger, J.J. (1987). Basic fluid power (pp. 18-28, 249-262, 299-317). Englewood Cliffs, NJ. Prentice-Hall, Inc. ISBN 0-13-061508-0 025
      6. Stewart, H.L. & Stover, J.M. (1966). ABC's of fluid power (pp. 7-15, & 120-126). Indianapolis, IN: Howard W. Sams & Co., Inc.

   B. Film slides/film/video

      Film (select a current title from the media sources in this guide's section III, Part 4).

   C. Field trips

      Visit a vocational school's automotive shop or a local plant that actually uses fluid power.

Management/Logistics:

1. **Related TAMS**

   TAM #8: Internal Combustion
   TAM #10: Fundamentals of Mechanical Power Transmission
   TAM #11: Electric Motor Control - Robotics

2. **Evaluation/Grading**

   A. 50% project
   B. 50% examinations

3. **Suggested Schedule/Time**

   The activities in this TAM should be completed in two to four weeks.

Key Instructional Suggestions:

1. **Safety**

   The instructor should double-check to ensure that all potential safety problems are addressed.

   A. Review general laboratory safety requirements with students.
   B. Review general safety rules for the operation of fluid-powered machines (eye protection in particular).

2. **Motivation**

   A. The instructor should display the best fluid power-related projects.
   B. Visit the vocational school's automotive shop or a local plant that actually uses pneumatics and hydraulics.

3. **Prerequisite Information**

   None, but a knowledge of basic algebra and physics would be an advantage.

4. **Demonstrations**

   A. How to make an object move using air.
   B. How to make an object move using fluid.
   C. How to operate the hydraulic/pneumatics trainer.

5. **Reinforcement**

   Interact with the school's physics instructor to work cooperatively on simple machines and fluids to work on fluid power.

6. **Attitudes**

   A. Encourage safety attitudes.
   B. Encourage work ethic.
   C. Encourage students to think of non-traditional applications for pneumatics and hydraulics.

7. **Remediation/Enrichment**

   Remediation: Have slower students work with the special needs instructor to bring their capabilities to the required levels.

Enrichment: Consider having advanced students experiment with more advanced principles of fluid circuitry, such as synchronization.

8. Summary & Review

A. Hydraulics - pertain to liquid pressure and flow
B. Pneumatics -pertain to gaseous pressure and flow
C. Safety rules and regulations.

9. Review Questions & Answers

A. List three general rules for deciding whether a pneumatic or hydraulic system should be used for an application.

- *If a great amount of force is required, use hydraulics.*
- *If high speeds and rapid response are desired, use pneumatics;*
- *If fine feeds are required, and if force is not an important factor, use a combination of pneumatics and hydraulics.*

B. Which type of fluid system is usually preferred when high speeds are desirable?

Pneumatic system

C. Which type of fluid system is preferable when low pressures are considered?

Hydraulic system

D. Compare the two fluid systems in their adaptability for operating in adverse atmospheres.

Pneumatic systems are also commonly employed in extremely dusty atmospheres which can, in many instances, be explosive in nature. Hydraulic systems also function in adverse atmospheres, but it may be necessary to add rather expensive materials and seals to cope with adverse conditions.

Date: ________ Class: ________ Name: ______________________________

TAM #9: Fundamentals of Fluid Power - Pre-test

Instructions: Fill in the blank space with the most suitable word(s)or sentence(s).

1. The word hydraulics in Greek means ________________.

2. The four physical properties of fluids are:

   A. ______________________________

   B. ______________________________

   C. ______________________________

   D. ______________________________

3. Pneumatics is a branch of physics concerned with ______________________

   ____

4. A pressure applied to a confined fluid at rest is transmitted with equal intensity throughout the fluid. Identify the law that states this principle.
   A. Boyles'
   B. Bernoulli's
   C. Charles'
   D. Pascal's

5. Hydraulic and pneumatic circuits are generally the same in principle. Both hydraulic and pneumatic circuits have ______________ major components.
   A. Four
   B. Six
   C. Eight
   D. Ten

6. The change in volume of a unit volume of a fluid when subjected to a unit change of pressure is called
   A. Fluid friction
   B. Flow rate
   C. Bulk modulus
   D. Compressibility

Date: ________ Class: ________ Name: ________________________

TAM #9: Fundamentals of Fluid Power - Post-test

Instructions: Read carefully each item and circle the letter of the correct answer

1. When designing a hydraulic circuit, these important considerations must be taken:
   - A. Safety and performance
   - B. Safety and efficiency
   - C. Performance and efficiency
   - D. All of the above

2. The advantages of water as the fluid in hydraulic systems are that it is:
   - A. Inexpensive and easy to clean
   - B. Easy to clean and readily available
   - C. Inexpensive and readily available
   - D. All of the above
   - E. None of the above

3. The common problems encountered with hydraulic pumps in a system are:
   - A. Doesn't deliver volume properly and system pressure is too low
   - B. Makes noise and shaft seal leaks
   - C. Excessive heat system pressure is too low
   - D. All of the above
   - E. None of the above

4. The piston of a spring-return single-acting air cylinder fails to retract to its original position when the air pressure is released. The probable causes are:
   - A. Broken spring and scored tube
   - B. Spring loses its tension and valve does not release full pressure
   - C. Broken spring and lack of lubrication
   - D. All of the above
   - E. Any of the above
   - F. None of the above

5. An air three-way control valve and an air two-way control valve do not operate properly. The probable causes are:
   - A. Tight ring and leaking packings
   - B. Tight ring and insufficient lubrication
   - C. Leaking packings and dirt particles in valve
   - D. All of the above
   - E. None of the above
   - F. A, B, or C

6. Using graphic symbols, draw a circuit with a hydraulic motor, an accumulator, a two-way cylinder, a reservoir and a three-way valve on the back of this page.

TAM #9: Fundamentals of Fluid Power - Test Keys

TAM #9 - Pre-test Answers

1. Water

2. A. Shapelessness of fluids
   B. Relative incompressibility of fluids
   C. Transmission of forces through fluids
   D. Pascal's Law

3. Physical behavior of air and other gases at rest, in motion and when compressed.

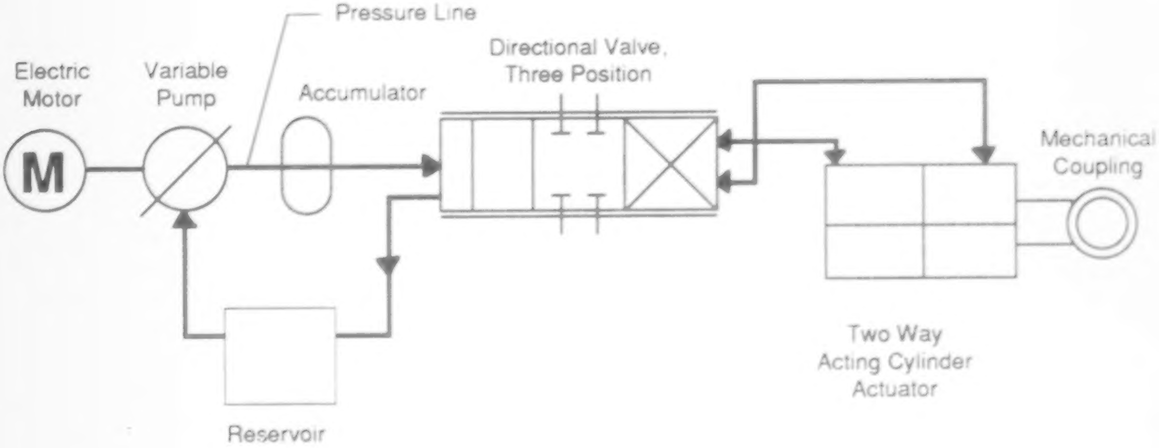
4. B

5. D

6. D

TAM #9 - Post-test Answers

1. D 2. D 3. D 4. E 5. F


Pressure Line
Electric Motor
M
Variable Pump
Accumulator
Directional Valve, Three Position
Mechanical Coupling
Reservoir
Two Way Acting Cylinder Actuator

TAM #9: Fundamentals of Fluid Power

Student Component

Introduction:

The purpose of this TAM is to provide you with a basic background to the vast field of fluid power. This TAM places emphasis on understanding how fluid systems operate and on practical applications. In this way you will learn not only the how, but the why of fluid power system operation.

Competencies: Following the completion of this TAM, you will be able to:

1. Describe the characteristics and advantages/disadvantages of two major types of power transmission system: pneumatics and hydraulics.
2. Develop an operational definition and concept of power systems.
3. Define the basic terms commonly used in power systems.
5. Describe the types of power systems used in our society.
6. Employ a systematic design process to produce a power transmission system that meets the assigned design specifications.
7. Describe the applications of pneumatics in a technological society.
8. Describe the applications of hydraulics in a technological society.
9. Construct fluid power systems utilizing typical components.
10. Manipulate common test instruments to analyze fluid power circuits.

Module Overview:

You may be aware that your body cannot move without muscle power. In much the same way, fluid power is the muscle that moves industry. This is because it is used to pull, push, regulate or drive almost all the machines in any modern industry. For example, fluid power is used for steering and braking automobiles, launching rockets, powering machine tools, controlling airplanes, and much more. Most manufactured products, in some stage of production or distribution, are fluid-powered.

Furthermore, fluid power is not just a powerful muscle that moves industry. It is a controlled, flexible muscle which provides power smoothly, efficiently, and safely.

The study of fluid power technology cannot be overemphasized when you consider the rapid growth of modern technology. Since the application of fluid power has become universal in recent years, there are some problems experienced by many people that are normally not dealt with in this context. You should be able to evaluate some of these problems and try to provide as many answers as possible.

Key Information:

1. Class Presentations

- How to design a simple hydraulic circuit (hydraulic power steering)
- How to design a simple pneumatic circuit (air compressor)

2. Demonstrations

- How to make an object move using air
- How to make an object move using water
- How to operate the hydraulic/pneumatics trainer

3. Safety

In the study of power fluid technology, you will come into contact with many things that require special care in the way they are used, handled, and stored. Safety habits cannot be overemphasized in this TAM. You should remember this when your instructor insists on safe work practices. They are in your best interest. Work at safety until it becomes a habit.

Major safety concerns to this TAM's activity are:

- Solvents, fuels or lubricants
- Safety goggles
- Waste disposal
- Ventilation
- Tools usage
- Hydraulic machinery
- Fluid-power machines
- Ear protectors

Glossary:

1. **Actuator** -- A cylinder, motor, or other converter that changes fluid pressure into the desired mechanical form.
2. **Capillarity** -- The rise and fall of a liquid in a small diameter tube.
3. **Filter** -- A device that cleans the fluid in the system.
4. **Fluid Power** -- The energy transmitted and controlled through the use of a fluid.
5. **Fluid Power System** -- A system which transmits and controls energy through the use of a fluid within an enclosed circuit.
6. **Fluids** -- Liquids and gases.
7. **Gases** -- Fluids which are readily compressible and variable in terms of volume.
8. **Hydraulics** -- The engineering science pertaining to liquid pressure and flow, or the science of liquids at rest and in motion, or when pressurized.
9. **Liquids** -- Substances which are capable of flowing and which conform to the shape of containing vessels.
10. **Pneumatics** -- The engineering science pertaining to gaseous pressure and flow, or to the science of air and other gases at rest, in motion and under pressure.
11. **Pressure** -- The force per unit area, usually expressed in pounds per square inch.
12. **Pump or Compressor** -- A device that converts mechanical power into fluid pressure differentials.
13. **Reservoir** -- A container that stores fluid.
14. **Specific Gravity** (liquid) -- The ratio of the weight of a given volume of liquid to the weight of an equal volume of water.
15. **Specific Weight** -- The weight of a unit volume of the substance.
16. **Transmission Lines** -- A system of pipes, hoses, and tubes. These parts contain the fluid which can be transmitted under pressure.
17. **Viscosity** -- The resistance of a fluid to flow, or a measurement of the ability of liquid to flow.

Needed Materials:

1. **Supplies Required**
    - A. Oil
    - B. Cylinder
    - C. Load plate
    - D. Weight set: 1 lb., 5 lb., 10 lb., 20 lb.
    - E. Syringes
    - F. Plastic tubing
    - G. Plywood for mounting power steering demonstration unit

2. **Equipment/Machines/Tools**
    - A. Hydraulics/pneumatics trainer complete with cylinders
    - B. Fractional horsepower motor
    - C. Power steering pump
    - D. Power steering actuator (rack and pinion type)
    - E. Power steering control valve
    - F. Air compressor
    - G. Air hose
    - H. Ruler
    - I. Pressure gauges

3. **Handouts**
    - A. Student component of TAM #9
    - B. Handout #1: Advantages & Basic Components of Fluid Power Systems
    - C. Handout #2: ANSI Symbols

TAM #9: Fundamentals of Fluid Power

Activity #1: Basic Principles of circuitry (Hydraulic Circuitry - Power Steering) - Plan of Procedure

A hydraulic circuit is a group of components such as pumps, cylinders, or motors (actuators), or control valves arranged to do work. Three important considerations in setting up a hydraulic circuit are safety, performance of desired function, and efficiency of operations.

Hydraulic circuits can be developed through the use of graphic symbols for all components. Therefore, it is necessary for you to know these fluid symbols. A list of ANSI symbols is provided in Handout #2. The power steering circuit to be set up is shown below (Figure #1).

1. Follow the directions in the circuit diagram provided by your instructor, and use the hydraulics/pneumatics trainer to set up the power steering circuit.

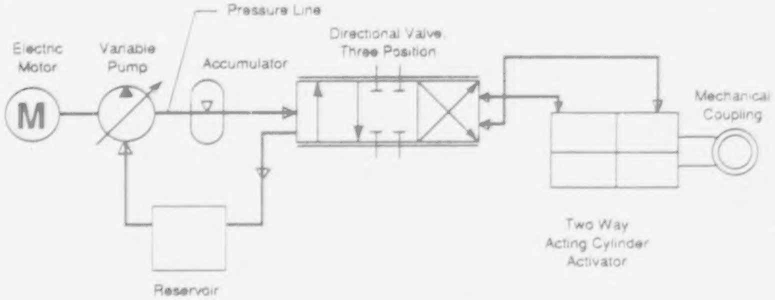

Pressure Line
Electric Motor
Variable Pump
Accumulator
Directional Valve, Three Position
Mechanical Coupling
M
Two Way Acting Cylinder Activator
Reservoir

Figure #1 - Power Steering Circuit

2. You can also build a hydraulic power steering circuit from salvaged automobile parts (Figure #2).

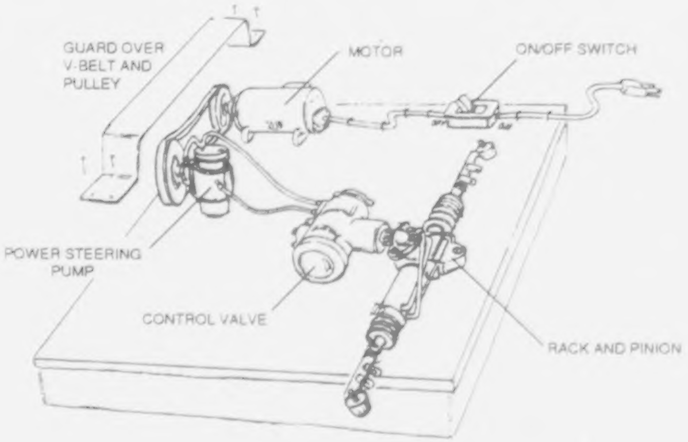

GUARD OVER V-BELT AND PULLEY
MOTOR
ON/OFF SWITCH
POWER STEERING PUMP
CONTROL VALVE
RACK AND PINION

Figure #2 - Power Steering Unit

3. Mount a fractional horsepower electric motor, an automotive power steering pump and reservoir securely on the base.

4. Connect the motor to the pump with V-Belts and be sure to cover the belts and pulleys with safety guards. Mount the power steering actuator (preferably a rack and pinion type) on the base.

5. Mount the power steering control valve on the base and connect the components according to the circuit diagrams and test for leaks.

Discussion: The fluid passes through a pressure regulator, which controls the amount of pressure to the power steering actuator. The four-way valve is controlled by the steering wheel. The fluid then pressurizes the power steering actuator (usually a hydraulic cylinder). This is where the energy is transformed from hydraulic energy to mechanical energy. The fluid is then returned to the reservoir. The mechanical energy from the actuator is transmitted to the steering linkage, which makes the car's wheels turn left or right (Figure #3).

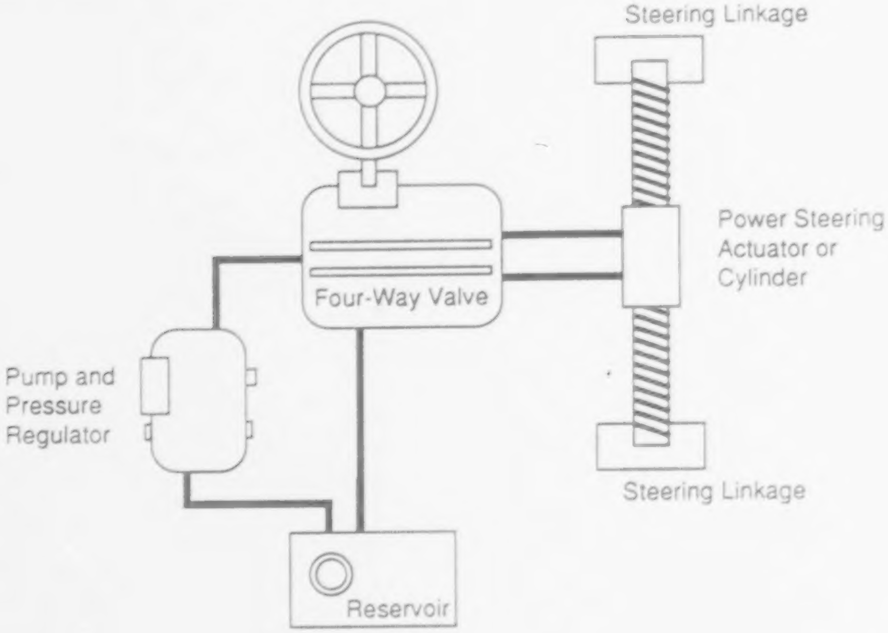

Steering Linkage
Power Steering Actuator or Cylinder
Four-Way Valve
Pump and Pressure Regulator
Steering Linkage
Reservoir

Figure #3 - Power Steering Circuit Model

Activity #2: How to set up a Simple Pneumatic Circuit (An Air Compressor) - Plan of Procedure

1. Follow the directions in the system diagram (see Figure #4).

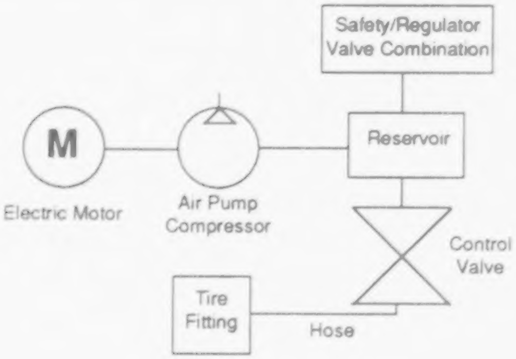

Safety/Regulator Valve Combination
M
Reservoir
Electric Motor
Air Pump Compressor
Control Valve
Tire Fitting
Hose

Figure #4 - Air Compressor Diagram

2. Note that the trainer's source of energy is an electric motor.
3. When the engine is turned on you will be able to observe that the energy is being transmitted to the compressor (via the belt). Inside the compressor, the energy is transmitted to air.
4. The compressed air is pumped into the pressure tank. The tank normally should have a regulator that keeps the pressure from getting too high. Safety also demands the use of a safety valve.
5. When one wants to fill a tire, the air flows from the tank, through a hose, to the valve. This valve allows you to transmit the air to the tire (Figure #5).

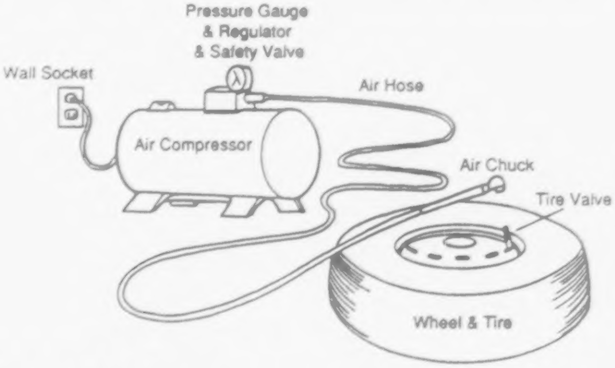

Pressure Gauge & Regulator & Safety Valve
Wall Socket
Air Hose
Air Compressor
Air Chuck
Tire Valve
Wheel & Tire

Figure #5 - Tire Inflation with Compressed Air

TAM #9: Fundamentals of Fluid Power

Activity #3: Differences Between Pneumatics & Hydraulics - Plan of Procedure

1. Set up two different circuits as shown in the diagram. Note that each uses two syringes and some connecting tubes. However, one system (the pneumatic one) uses air as its working fluid, while the other (the hydraulic one) uses water as the working fluid. Add a drop of food coloring to the water to make it more visible (Figure #5).

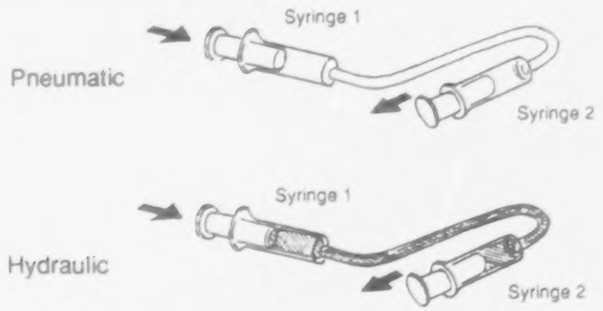


Figure #5 - Syringe Setups

2. Using a two-syringe system (one in each hand), you can force one syringe by exerting pressure on the other. Push the plunger in the right-hand syringe and feel the pressure changes which are transferred into the left hand (Figure #6).

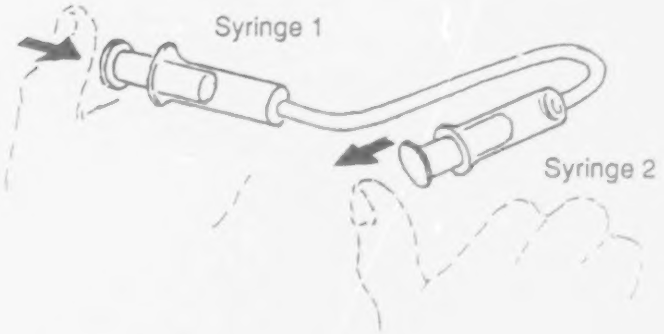


Figure #6 - Syringe Pressure Test Unit

3. What changes did you feel? Continue to squeeze the right hand syringe until the pressure of the working fluid forces your hand out, or finds its own outlet somewhere else.

4. Record your findings.

5. Using a three syringe system as shown in the diagram below, you can cause the same movement observed in step #2 above; however, now in multiple directions (Figure #7).

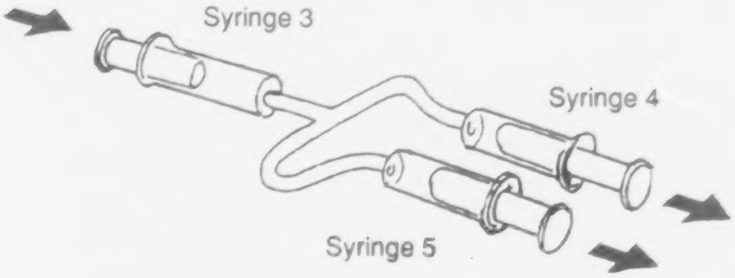


Figure #7 - Multiple Syringe Configuration

Activity #4: Differences Between Pneumatics & Hydraulics - Plan of Procedure

Hydraulic

1. Set up the circuit using an oil filled cylinder as shown in view A of the diagram.
2. Measure the height of the load plate from the cylinder top.
3. Apply 20 pounds of weight to the hydraulic cylinder's load plate.
4. Observe what happens.
5. Measure the height of the load plate from the cylinder.
6. Repeat the steps with different weights.
7. Record your findings.

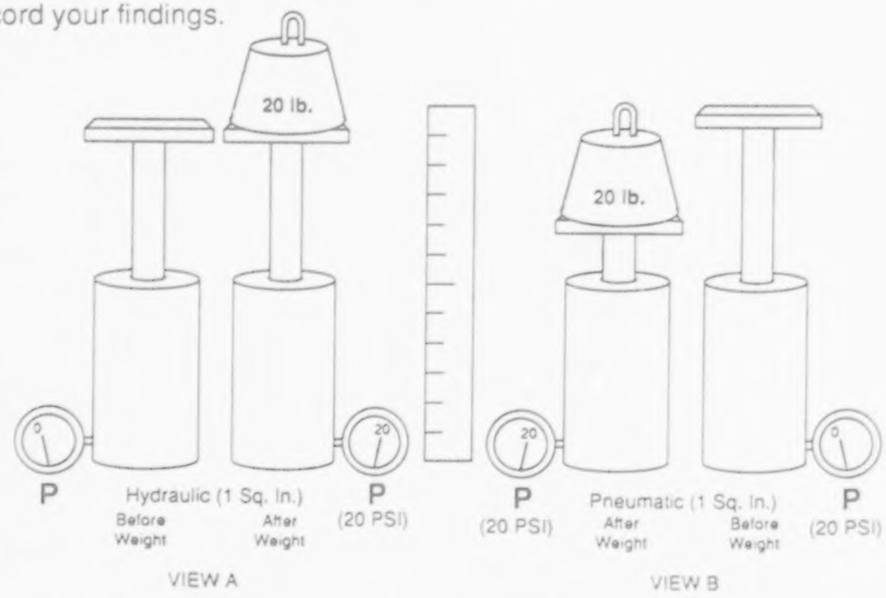

20 lb.
20 lb.
0
20
20
0
P
Hydraulic (1 Sq. In.)
Before Weight
After Weight
P
(20 PSI)
P
(20 PSI)
Pneumatic (1 Sq. In.)
After Weight
Before Weight
P
(20 PSI)
VIEW A
VIEW B

Figure #8 - Hydraulic/Pneumatic Comparison

Pneumatic

8. Set up the circuit using an air-filled cylinder as shown in view B of the diagram.
9. Measure the height of the load plate from the cylinder top.
10. Apply 20 pounds of weight to the pneumatic cylinder.
11. What did you observe?

12. Measure the height of the load plate from the cylinder.
13. Repeat step #3 with different weights.
14. Record your observations.
15. What differences did you find between the pneumatic and the hydraulic activities?
16. Write a technical report of your experiment.

TAM #9: Fundamentals of Fluid Power

Activity #5: Hydraulic Advantage - Plan of Procedure

1. Use a hydraulic trainer to set up a circuit as shown in the diagram (Figure #9).

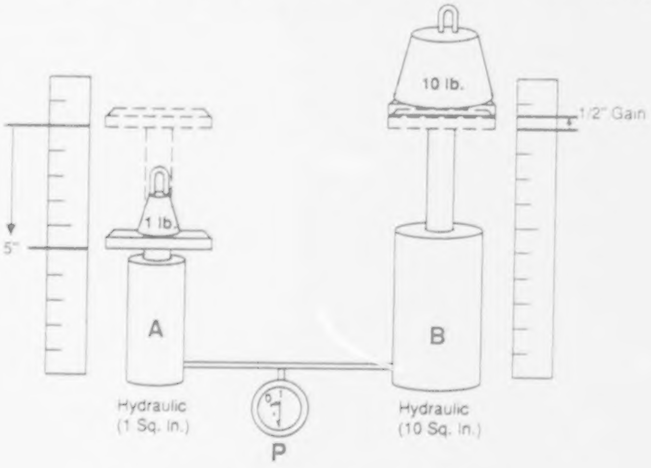


Figure #9 - Hydraulic Illustrator

2. Measure both cylinder's load plate heights.
3. Load the small cylinder with a 1 pound weight.
4. Record the circuit pressure.
5. What happens to the liquid which has been placed under pressure?
6. What happens to the cylinder load plates?
7. Repeat these steps with different weights after first pushing down cylinder B manually.
8. Record your observations in your notebook.
9. Research the topic of mechanical advantage.
10. Use your results to calculate the mechanical advantage of this system.
11. Write a technical report explaining your observations and conclusions.

TAM #9 - Summary

1. **Review & Summary Activities**

   The general impact of fluid power in the modern world today is great, although a lot of people take it for granted. However, you have become aware of the usefulness of fluid power and its importance for improving our standard of living. The fantastic growth of this new and exciting technology is creating many new opportunities for trained personnel in all phases of fluid power. The activities you learn in this TAM will no doubt help you understand the basic fundamentals of fluid power which you can transfer to other areas as required.

2. **Review Questions -- Test yourself!**

   A. Demonstrate Pascal's Law using equipment borrowed from the Science Department.

   B. Explain why liquids will follow the path of least resistance.

   C. What hydraulic device is used to create force that can push or pull a load?

   D. Why must the gas in a pneumatic system be stored at a pressure much higher than needed to do the required work?

   E. Describe briefly how pneumatic systems are used in five different devices.

   F. What is free air?

TAM #7 - Post-assessment

Instructions:

1. Have the instructor assess your designs of simple hydraulic and pneumatic circuits and the activities you performed on how to make an object move using both air and water.
2. Complete the post-test for TAM #9.
3. If your results demonstrate mastery, then go on to the next activity or TAM assigned by your instructor. If less than completely successful, check with your instructor and plan what to do to raise your level.

TAM #9 - Handout 1

Advantages & Basic Components of Fluid Power Systems

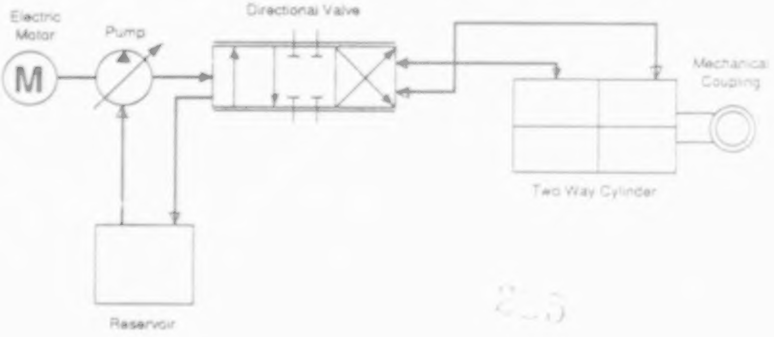
1. Fluid power gives flexibility in the control of machines.
2. Fluid power gives an efficient method of multiplying forces.
3. Fluid power gives constant torque at infinitely variable speeds in either direction with smooth reversals.
4. Fluid power is compatible with other means of control, such as electrical, electronic, or mechanical.
5. Fluid power is accurate and provides quick response to controls.
6. Small forces can be expanded to control large forces.
7. Oil fluid power gives automatic lubrication for less wear.
8. Air fluid power is clean and safe from fire hazards.
9. Fluid power gives freedom in machine design.
10. Fluid power is not difficult and provides ease of installation and maintenance.
11. Fluid power is economical, efficient and dependable.
12. Fluid power is generally available and provides predictable performance.

-- Adapted from Pease & Pipenger, 1987

Components of Fluid Power Systems

Generally, all hydraulic and pneumatic circuits are the same in terms of importance, regardless of the application. In both hydraulic and pneumatic circuits, they have six major components:

1. A reservoir (tank) for holding the liquid (hydraulic oil), or air in pneumatic.
2. A pump for forcing the liquid through the system in hydraulic systems/applications, while in pneumatic systems/applications a compressor to compress air is required.
3. A power source (an electric motor) to drive the pump or the compressor.
4. Valves for controlling the direction of liquid or air, pressure and flow rate.
5. Actuators (cylinder or motor) for converting energy into mechanical force to perform work.
6. Piping for carrying liquid in hydraulic systems/applications, and for carrying pressurized air in pneumatic systems/applications, from one location to another.



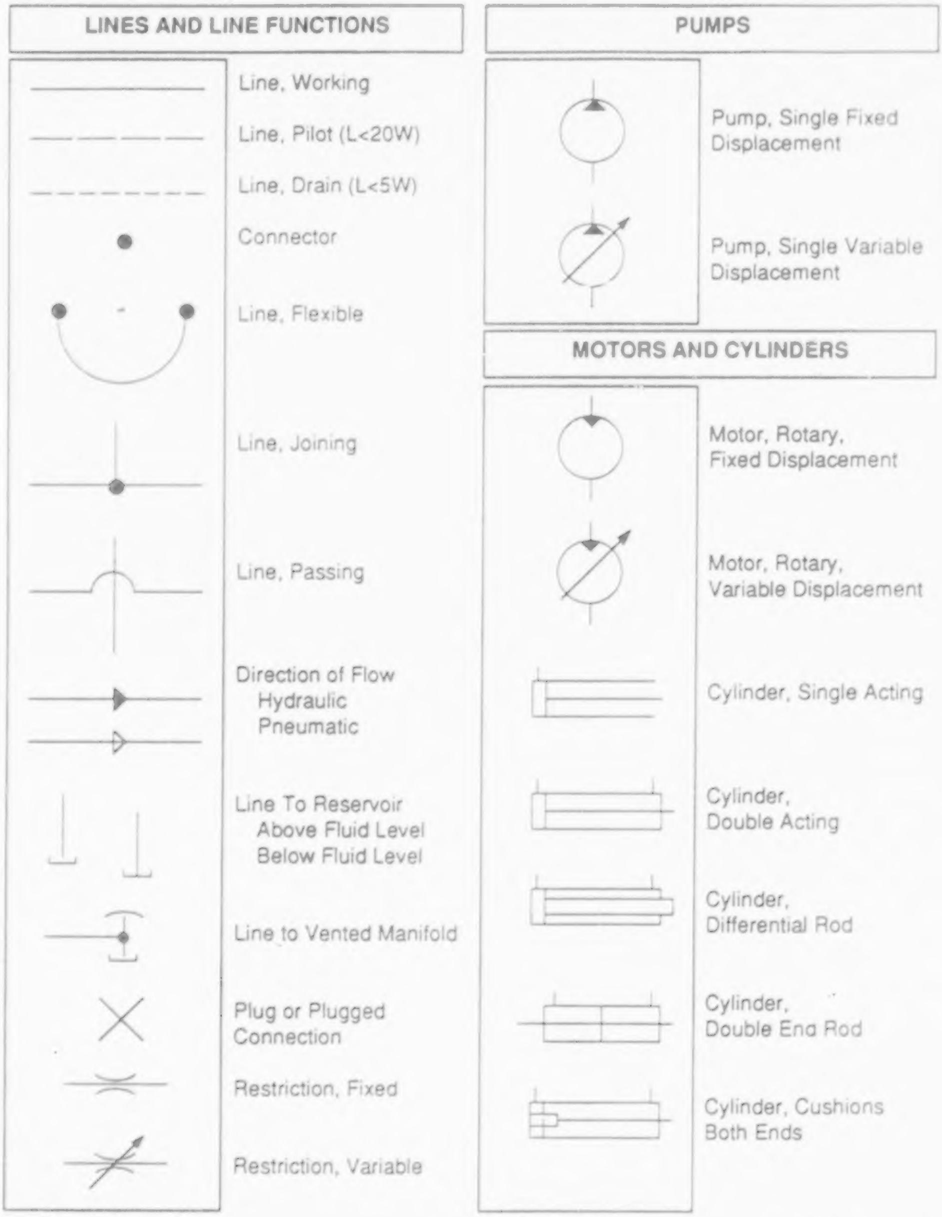
TAM #9 - Handout 2

ANSI Symbols

A hydraulic circuit is a cluster of components composed of units such as pumps, cylinders, or motors (actuators), and control valves which are configured to do useful work. There are three primary considerations to consider when designing a hydraulic circuit: (1) safety, (2) performance, and (3) efficiency.

Generally, hydraulic circuits are developed through the use of graphic symbols. Various ANSI symbols, represented below, will be used at various points throughout the TAM.

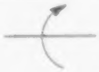
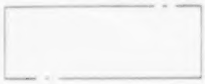
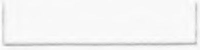
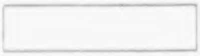
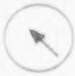
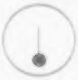
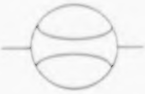
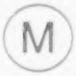
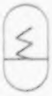
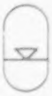
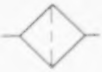
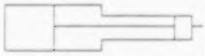
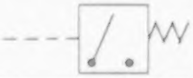
ANSI Symbols in Hydraulic Components


LINES AND LINE FUNCTIONS
Line, Working
Line, Pilot (L<20W)
Line, Drain (L<5W)
Connector
Line, Flexible
Line, Joining
Line, Passing
Direction of Flow
Hydraulic
Pneumatic
Line To Reservoir
Above Fluid Level
Below Fluid Level
Line to Vented Manifold
Plug or Plugged Connection
Restriction, Fixed
Restriction, Variable
PUMPS
Pump, Single Fixed Displacement
Pump, Single Variable Displacement
MOTORS AND CYLINDERS
Motor, Rotary, Fixed Displacement
Motor, Rotary, Variable Displacement
Cylinder, Single Acting
Cylinder, Double Acting
Cylinder, Differential Rod
Cylinder, Double End Rod
Cylinder, Cushions Both Ends

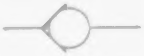
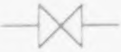
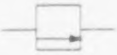
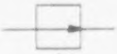
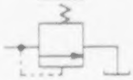
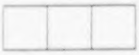
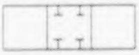
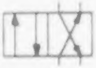
TAM #9 - Handout 2

ANSI Symbols (p. 2)

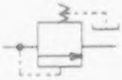
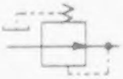
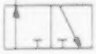
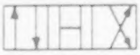
MISCELLANEOUS UNITS

	Direction of Rotation (Arrow in front of shaft)
	Component Enclosure
	Reservoir, Vented
	Reservoir, Pressurized
	Pressure Gage
	Temperature Gage
	Flow Meter (Flow Rate)
	Electric Motor
	Accumulator, Spring Loaded
	Accumulator, Gas Charged
	Filter or Strainer
	Intensifier
	Pressure Switch

BASIC VALVE SYMBOLS

	Check Valve
	Manual Shut Off Valve
	Valve, Single Flow Path, Normally Closed
	Valve, Single Flow Path, Normally Open
	Valve, Maximum Pressure (Relief)
	Basic Valve Symbol, Multiple Flow Paths
	Flow Paths Blocked in Center Position
	Multiple Flow Paths (Arrow shows flow direction)

VALVE EXAMPLES

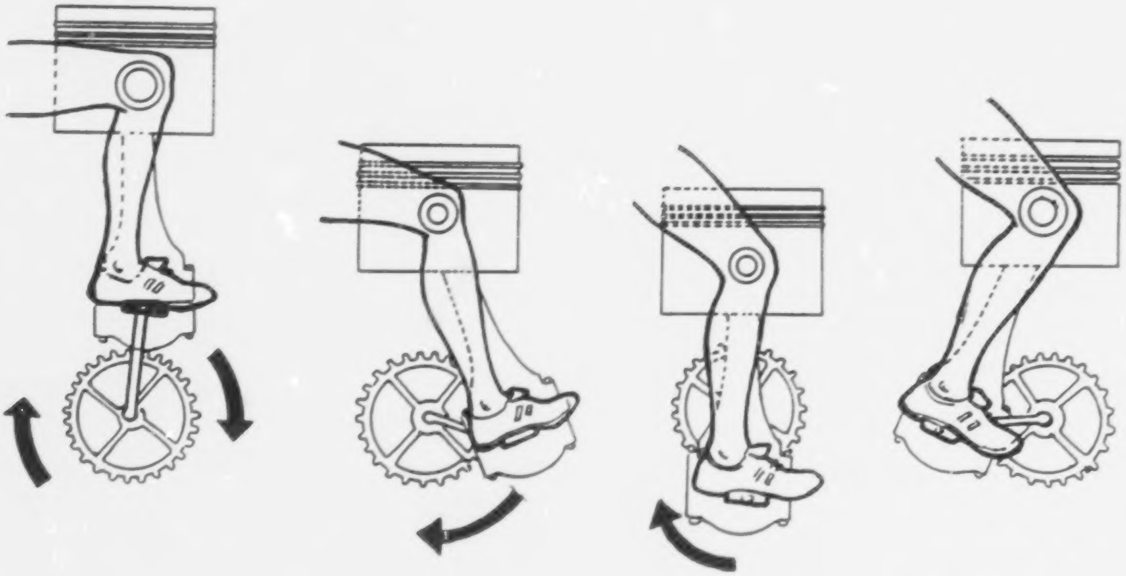
	Sequence Valve, Directly Operated, Externally Drained
	Pressure Reducing Valve
	Directional Valve, Two Position, Three Connection
	Directional Valve, Three Position, Four Connection

Course: Introduction to Energy & Power Technology

Technology Activity Module #10

Fundamentals of Mechanical Power Transmission

by: Tim Trogdon



TAM #10: Fundamentals of Mechanical Power Transmission

Instructor Component

Activity Objectives: **The purpose of this activity is to provide the opportunity to learn about mechanical principles and their transmission into energy and motion control.**

Activity Competencies: By completing this TAM, the student will be able to:

1. Illustrate and explain the six simple machines and their applications.
2. Employ a systematic design process to produce a power transmission system that meets the assigned design specifications.
3. Explain lubrication systems, their function and importance in transportation and industry.
4. Read technical and working drawings to secure needed information.
5. Build demonstrator power conversion and transmission devices.
6. Explain the basic concepts of mechanical transmission system.
7. Use tools and equipment to assemble mechanical power transmission systems and mechanisms.

Module Instructions

Introduction:

This activity is designed to let the student see how simple and complex mechanisms have been used to control motion, transmit energy and gain mechanical advantage through various components such as gears, pulleys, levers and linkages. Many different mechanical devices can be used to apply mechanical advantage. Human power was chosen as the focus for this activity due to its appeal and efficient use of mechanical components. The activities contained in this unit will allow students the opportunity to solve theoretical problems in a hands-on situation and progress to the problem-solving design level where a human power tractor could be designed and built.

Safety Considerations:

The proper and safe use of mechanical components needs to be emphasized. Machines under stress become unstable and could fail structurally. Because of this possibility, the use of protective helmets and clothing is strongly recommended. All mechanical components which are in motion should be shielded with guards.

Needed Materials:

1. **Supplies Required**
    - A. Fischertechnik Start 100/1 Set (NOTE: Although this TAM was developed using the Fischertechnik system, other systems, such as Lego® or Erector, could also be used or constructed)
    - B. Bicycle
    - C. Gears
    - D. Metal tubing
    - E. Wood
    - F. Hardware items
    - G. Goggles
    - H. Sheet metal

2. **Equipment/Machines/Tools**
    - A. Metal andsaw
    - B. Drill Press
    - C. Power miter saw

3. **Handouts**
    - A. Student component of TAM #10
    - B. Problem Solving Observation Form

4. **Instructional Resources**
    - A. Catalogs (construction equipment & materials)
        1. Tim King Electronics (Fishertechnik Components)
        2. Stock Drive Components (Automate System)
        3. Electronic Controls and Systems (Unilab)
    - B. Books and Articles
        1. Bailye, O., Pickup, R., Lewis, L.,& Patient, P. (1981). Modular courses in technology: Mechanisms. Edinburgh: Oliver & Boyd. ISBN # 0 05 003386 7
        2. Fowler, P. & Horsley, M. (1988). Collins cdt: Technology. London, England: Collins Educational. ISBN # 0 00327434-9, 123-151.
        3. Todd, R., McCrory, D., & Todd, K. (1985). Understanding and using technology (pp. 11-31). Worcester, MA: Davis Publication, Inc. ISBN 0-087192-165-0
        4. Martin, Scott. (1988, December). Human power. Bicycling Magazine, 29, p. 66-72.
        5. Hutchinson, P. (1988, October). The bike: No obsolescence in sight. Ties Magazine pp. 29-32.
        6. Langford, J. (1988, August). Triumph of Daedalus. National Geographic, p. 191-199.
        7. Allen, B. (1979, November). Winged victory of "Gossamer albatross." National Geographic.
    - C. Film slides/film/video
        1. Video from National Geographic on the flight of the Daedalus
        2. Video of Human Power Helicopters
        3. Beyond 2000 episodes

D. Speakers

   1. A guest lecturer from a local bicycle shop could describe how the bicycle works, including its strengths and weaknesses.

E. Write or call the International Human Vehicle Association and share findings with the class.

Management/Logistics:

1. Related TAMS

Two TAMS from the Missouri Introduction to Materials and Processing Guide may be useful in working through this TAM:

- TAM #2 - Problem Solving
- TAM #5 - Non-destructive Testing

2. Evaluation/Grading

The evaluation procedure suggested is a combination of written and performance-based testing from the lab activity. An evaluation critique sheet for the design problem activity is provided.

3. Suggested Schedule/Time

The suggested time period for this TAM is two to four weeks.

Key Instructional Suggestions:

1. Safety

The precautions for these activities include normal guidelines students would follow while working in a lab. In addition to these, the following are suggested for the design problem activity:

- Use guards on all exposed gears and mechanisms.
- Check for structural integrity of all fastening methods and materials used on the vehicles before actually testing them.
- Protective helmets, glasses, clothing, and shoes should be worn while testing and using the vehicles.
- Permission from parents or guardians should be obtained before letting the students compete in the event.
- It is recommended that liability release waivers be obtained from all participants prior to participation in the pull event.

2. Motivation

The instructor is encouraged to secure examples of how mechanical devices have been and are being used in society to make our lives easier, including samples from industry and the home. The students might be assigned to find historical examples and develop a pictorial.

Planning can also be done to organize and develop a competitive human tractor pull event.

3. Prerequisite Information

To complete these activities, very little prerequisite information is needed. The instructor is encouraged to develop a file of information sheets or procedures for students to refer to when fastening metal tubes and rods together.

4. Demonstrations

The instructor should demonstrate the techniques for fastening components together for activity number one.

The instructor should prototype a design for a human-powered tractor using straws or modeling balsa.

5. Reinforcement

This TAM provides an excellent opportunity to reinforce basic principles of physics such as friction, gear ratios, efficiency, torque, and more. The uses of mechanical energy transmission in society should be stressed. Even though our society is in the information age, which is relying more and more on the computer, the mechanical components which transport materials and goods remain vital to society.

6. Attitudes

By developing models, procuring audio-visual information, and being enthusiastic, a carry-over of excitement will help the student's attitude towards the activity.

7. Remediation/Enrichment

Remediation: Grouping students in pairs will facilitate the activity. Use many graphic and physical examples in the lessons to help bypass potential problems.

Enrichment: You may wish to get the students involved in the design and construction of the "Human Powered Tractor Pull Cart" (See Figure #1). Students can then provide leadership in developing and organizing a competitive human-powered "Tractor Pull". Remember, this kind of activity is good press for your program. Students can promote the event by preparing a news release and contacting the local media for coverage.

8. Summary & Review

The following are key points which the instructor should summarize:

A. What are gears and levers?
B. What is the tradeoff for increased torque in a gearing system?
C. How efficient are mechanical transmission systems?
D. How can the efficiency be improved?
E. What is the future of mechanical transmission systems?

9. Review Questions & Answers *(Answers are in italics)*

A. Gears are what class of leverage? *(first class)*

B. What are the four types of motion? *(rotary, linear, reciprocating, oscillating)*

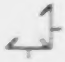
Date: ________ **Class:** ________ **Name:** ______________________________

TAM #10: Fundamentals of Mechanical Power Transmission - Pre-test

Instructions: Circle the correct answer.

1. The screw is what type of lever?
   A. Wheel and axle
   B. Inclined plane
   C. Third class lever
   D. Second class lever

2. What is used to reduce resistance in mechanical systems?
   A. Friction
   B. Lubrication
   C. Mechanical advantage
   D. Leverage

3. The following schematic symbol  represents:
   A. Bevel gears
   B. Compound gears
   C. Torque
   D. Pneumatics

4. Which is the correct order for the universal model as it relates to mechanisms?
   A. Input (force), process (gears), output (increased force)
   B. Process (gears), output (increased force), input (force)
   C. Output (increased force), input (force), process (gears)

5. Which one of the following tools **does not** apply torque?
   A. Tire wrench
   B. Ratchet
   C. Hammer
   D. Screwdriver

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #10: Fundamentals of Mechanical Power Transmission - Post-test

Instructions: Answer each question in the space provided. Use complete sentences.

1. Describe the purpose of levers.

2. List five types of lubricants which could be used to reduce resistance.

3. Draw a schematic diagram of four gears (one being compound) transmitting energy.

4. Choose a mechanical device in a typical home and describe the mechanical operation.

5. List five tools which were used to help you in the activities in this lesson.

TAM #10 - Test Keys

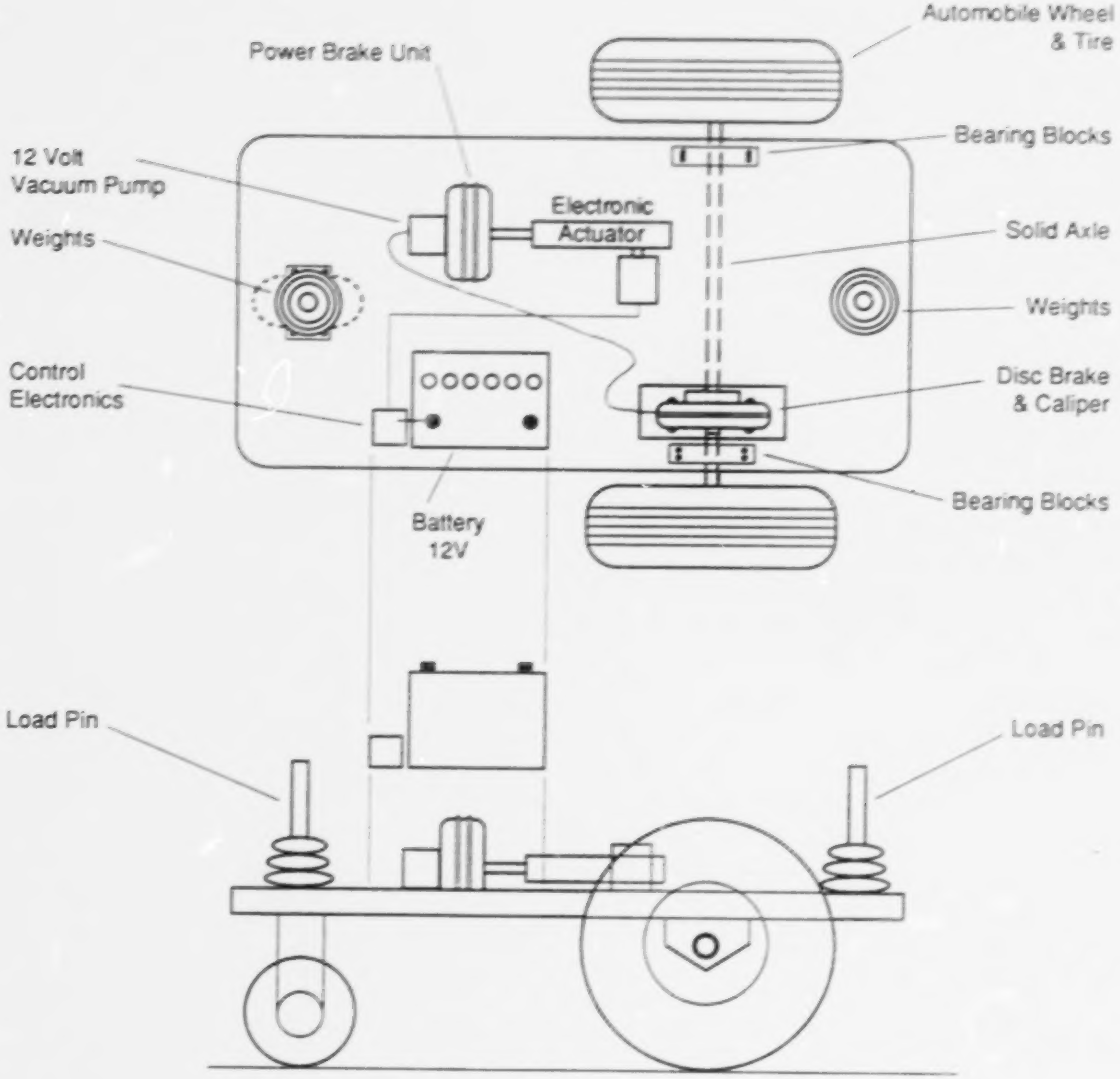
TAM #10 - Pre-test Answers

1. B 2. B 3. A 4. A 5. C

TAM #10 - Post-test Answers

The answers required for the post-test will vary with the student. Therefore, the answers will be reviewed by the instructor for appropriate responses. A checklist generated by the instructor would increase the accuracy of the grading with respect to the content being measured.

Instructional Sheet - Human Powered Tractor Pull Cart Concept


Automobile Wheel & Tire
Power Brake Unit
Bearing Blocks
12 Volt Vacuum Pump
Electronic Actuator
Solid Axle
Weights
Weights
Control Electronics
Disc Brake & Caliper
Bearing Blocks
Battery 12V
Load Pin
Load Pin

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TAM #10: Fundamentals of Mechanical Power Transmission

Student Component

Introduction:

The use of mechanical components dates back to the beginning of time. People have always found a need to control motion and transfer energy. Early examples include using a stick to gain mechanical advantage for prying rocks loose and harnessing the energy of a spring to a bow and arrow for hunting. Both of these early inventions are tools (machines) used to extend human reach and strength. Today, tools (machines) are more sophisticated due to the increase in technology, such as cars, computer-controlled lathes, and cranes, but the fundamental principles which are used have stayed the same.

Competencies: Following the completion of this TAM, you will be able to:

1. Illustrate and explain the six simple machines and their applications.
2. Employ a systematic design process to produce a power transmission system that meets the assigned design specifications.
3. Explain lubrication systems, their function and importance in transportation and industry.
4. Read technical and working drawing and prints to secure needed information.
5. Build demonstrator power conversion and transmission devices.
6. Explain the basic concepts of mechanical transmission system.
7. Use tools and equipment to assemble mechanical power transmission systems and mechanisms.

Module Overview:

This module is designed to give you a chance to explore automation using working models developed by you with Fishertechnic equipment. When you are finished with this lesson, you will be able to identify examples of automation around you.

Activity Sequence:

A. Participate in your instructor's start-up activities and presentation for this TAM. Follow all instructions, e.g., read the assigned material and review the steps of procedure.

B. Complete the pre-test given by your instructor.

C. Do Activity #1 - Mechanical Advantage and Control.

D. Do Activity #2 - The Human Powered Tractor.

E. Review and summarize.

F. Complete post-assessment procedure.

Key Information:

1. Class Presentations

This would be a good opportunity to invite an individual from a bicycle club or dealership to talk with the class about various design and structural features. Films from the Human Powered Vehicle Association are also available for use in stimulating enthusiasm and conveying useful information.

2. Demonstrations

- The assembly of the Fishertechnik components.
- Various fastening techniques that could be used in the construction of a pulling vehicle.
- How bicycle gearing works.

3. Safety

Caution should be taken during the design and construction phases of the Human Tractor Pulling vehicle to eliminate the possibility for personal injury. All gears should be shielded with appropriate guards. Additional precautions include requiring helmets and other protective clothing, as appropriate, as well as obtaining participant release forms prior to participation.

4. Personal Activity

Before beginning work on these activities, it is recommended that you read:

A. Bailye, O., Pickup, R., Lewis, L., & Patient, P. (1981). Modular courses in technology: Mechanisms. Edinburgh: Oliver & Boyd. ISBN # 0 05 003386 7.

B. Fowler, P. & Horsley, M. (1988). Collins cdt: Technology (pp. 123-151). London, England: Collines Educational. ISBN # 0 00327434-9

C. Todd, R., McCrory, D., and Todd, K. (1985). Understanding and using technology (pp. 11-31). Worcester, MS: Davis Publication, Inc. ISBN # 0-087192-165-0

Glossary:

1. **Bearing** -- A mechanical device which reduces friction.
2. **Control** -- The directing of energy, force and motion for a specific outcome.
3. **Coupling** -- A device used to connect the output energy of a machine to a shaft.
4. **Efficiency** -- The amount of energy actually used to accomplish work.

$$\text{Efficiency} = \frac{\text{MA} \times 100\%}{\text{VR}}$$

5. **Force** -- The amount of effort needed to move a load.
6. **Friction** -- The resistance between two moving parts.
7. **Fulcrum** -- A pivot point of a lever.
8. **Lever** -- A mechanical device which amplifies or reduces an input force. The three basic classes of levers are first, second, and third.
9. **Linkage** -- A mechanical means of energy transmission which includes leverage and changing direction, typically linear motion.
10. **Machine** -- A device which has moving parts and does work.
11. **Mechanical Advantage** -- Increasing a small force into a larger force through levers. The formula is:

$$\text{MA} = \frac{\text{Load (expressed in pounds or newtons)}}{\text{Effort (expressed in pounds or newtons)}}$$

12. **Motion** -- The movement of an object which could be rotary, linear, oscillating, or reciprocating.
13. **Pulley** -- A type of mechanism which uses rotary motion in which the input or output is through a belt.
14. **Torque** -- The measurement of turning effort
15. **Velocity Ratio** -- The ratio of distance moved by the effort to the distance moved by the load. The formula is:

$$\text{VR} = \frac{\text{Distance moved by the effort}}{\text{Distance moved by the load}}$$

16. **Work** -- The movement of an object over a distance in a specific time period.

Needed Materials:

1. **Supplies**
   - A. Activity #1 - Fischertechnik components
     1. 1 - gear with 40 teeth
     2. 2 - gears with 30 teeth
     3. 2 - gears with 20 teeth
     4. 1 - gear with 10 teeth
     5. 3 - hubs
     6. 3 - stainless steel rods 30 centimeters long
     7. 6 - 30 centimeter blocks
     8. 2 - 15 centimeter blocks
     9. 1 - base plate

   - B. Activity #2
     1. Bicycle
     2. Gears
     3. Metal tubing
     4. Wood
     5. Hardware items
     6. Sheet metal

2. **Equipment**
   - A. Activity #2
     1. Metal Bandsaw
     2. Drill Press
     3. Power Miter Saw

3. **Handouts**
   - A. Student component of TAM #10
   - B. Problem Solving Observation Form

TAM #10: Fundamentals of Mechanical Power Transmission

Activity #1: Mechanical Advantage and Motion Control - Plan of Procedure

Two Gear Energy Transmission System

1. Refer to the equipment list and obtain the following components:
   - A. One 40 tooth gear
   - B. one 20 tooth gear
   - C. Two rods
   - D. Base plate
   - E. Six large grey blocks
   - F. Two small grey blocks
2. Assemble the following diagram (Figure #1).

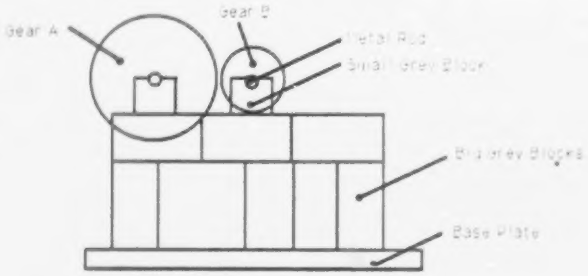


Figure #1 - Gear Assembly A

3. Count the number of teeth of the large gear (A) and write down the answer.
4. Count the number of teeth on the small gear (B) and write down the answer.
5. Assume that the drive gear is the gear (A). Calculate the mechanical advantage and write it down (state as a ratio).
6. If gear (A) is moving clockwise, determine the direction of gear (B) and write it down.
7. If gear (A) is the drive gear, determine whether the torque of gear (B) would be increased or decreased.
8. What would happen to the torque of the system if the drive gear was gear (B)?

9. Assemble the following by sliding gear (B) down and attaching a chain (Figure #2).

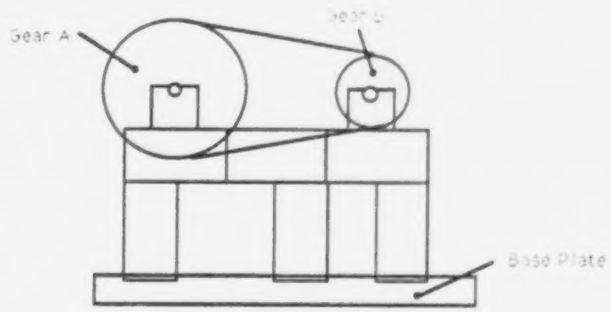


Figure #2 - Gear Assembly B

10. What would happen to the answers for question 6, 7, and 8 if a chain was used instead of a direct connect linkage?

11. How could you reverse gear (B)?

12. What are the disadvantages of using a chain or pulley for linking two gears together?

Compound Gear Energy Transmission System

1. Refer to the equipment list and obtain the following components.
   A. One 40 tooth gear
   B. One 20 tooth gear
   C. One 10 tooth gear
   D. One 30 tooth gear
   E. Three rods
   F. Base plate
   G. Six large grey blocks
   H. Two small grey blocks

2. Assemble the following (Figure #3).

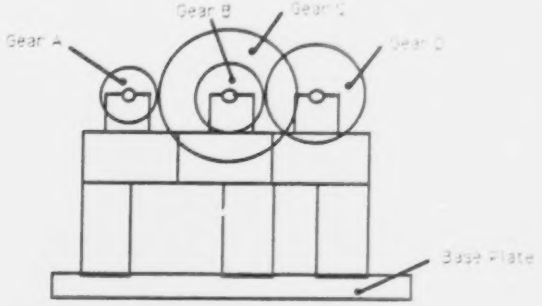


Figure #3 - Gear Assembly C

3. Count the number of teeth of the gears (A), (B), (C), and (D) then write down the answers.
4. Assume that the drive gear is the gear (A). Calculate the mechanical advantage through the system from (A) to (D) and write it down (State as a ratio).
5. If gear (A) is moving clockwise, determine the direction of gear (D) and write it down.
6. Determine whether the torque of gear (B) would be increased or decreased.
7. What would happen to the torque of the system at gear (A) if the drive gear was gear (D)?

Three-speed Transmission of Energy

1. Refer to the equipment list and obtain the following components.
    A. One 40 tooth gear
    B. Two 20 tooth gears
    C. One 10 tooth gear
    D. Two 30 tooth gears
    E. Three rods
    F. One base plate
    G. Six large grey blocks
    H. Two small grey blocks
2. Assemble the following (Figure #4).

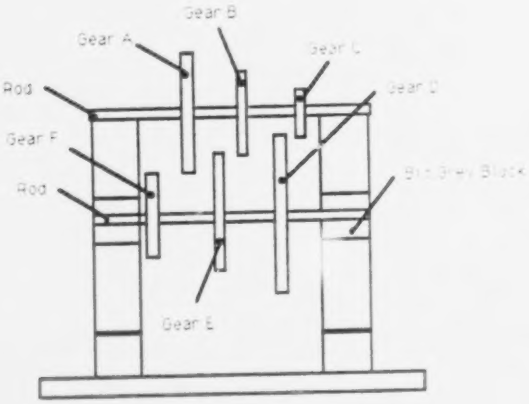


Figure #4 - Gear Assembly D

3. Count the number of teeth of the gears (A), (B), (C), (D), (E), and (F), then write down the answers.
4. Assume that the top rod is the shaft in which the power is being applied. Gears (A), (B), and (C) are on this rod.
5. Calculate the ratio for the following set of gears: (C) to (D), (B) to (E), and (A) to (F).
6. Determine which ratios are first gear, second gear, third gear, and neutral of a typical car.

7. Using this model, describe a way to make sure that the gears could shift when the drive rod (the top one) is or could be connected to a car engine (Note: a type of clutching system would be necessary).
8. Using this model describe a way to make sure that the gears ratios could be changed if this was a bicycle where the top rod is the crank and the bottom rod is the rear wheel.

Transmission of Energy at Angles

1. Refer to the equipment list and obtain the following components.
   A. One 40 tooth gear
   B. One 10 tooth gear
   C. Two rods
   D. One base plate
   E. Six large grey blocks
   F. Two small grey blocks

2. Assemble the following (Figure #5).

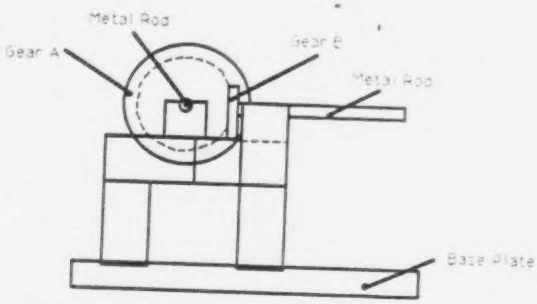


Figure #5 - Gear Assembly E

3. Count the number of teeth of the large gear (A) and write down the answer.
4. Count the number of teeth on the small gear (B) and write down the answer.
5. Assume that the drive gear is the gear (A). Calculate the mechanical advantage and write it down (state as a ratio).
6. If gear (A) is moving clockwise, determine the direction of gear (B) and write it down.
7. Using this model as a guide, describe how it could be modified to be used as differential of a car.

TAM #10: Fundamentals of Mechanical Power Transmission

Activity #2: The Human Powered Tractor - Plan of Procedure

This particular activity is designed for you to apply the principles of energy transmission by designing and building a mechanism that will be powered only by the energy from a human body. This activity will use the problem-solving method to help you accomplish your task.

The event will be a competition with two categories: (a) the Ultra Light division and the (b) Open division. The riders will be trying to pull a weighted cart which increases its own rolling resistance.

The **Ultra Light** division will be judged on the following criteria:

- The ratio of the total weight of the vehicle and rider to the distance pulled.
- There are no other energy devices on the vehicle, such as batteries or motors.

The **Open Division** will be judged on the following criteria:

- The distance pulled by the rider.
- The weight of the rider and vehicle cannot exceed three hundred pounds.
- There are no other energy devices on the vehicle, such as batteries or motors.

1. Review the Problem-solving handout.

2. Rewrite the problem statement in your own words.

3. List all the solution criteria for the problem.

4. Develop six possible solutions (for ideas, refer to the graphic concepts pictured on page 10 - Figure #6). Don't limit the possibilities to these concepts.

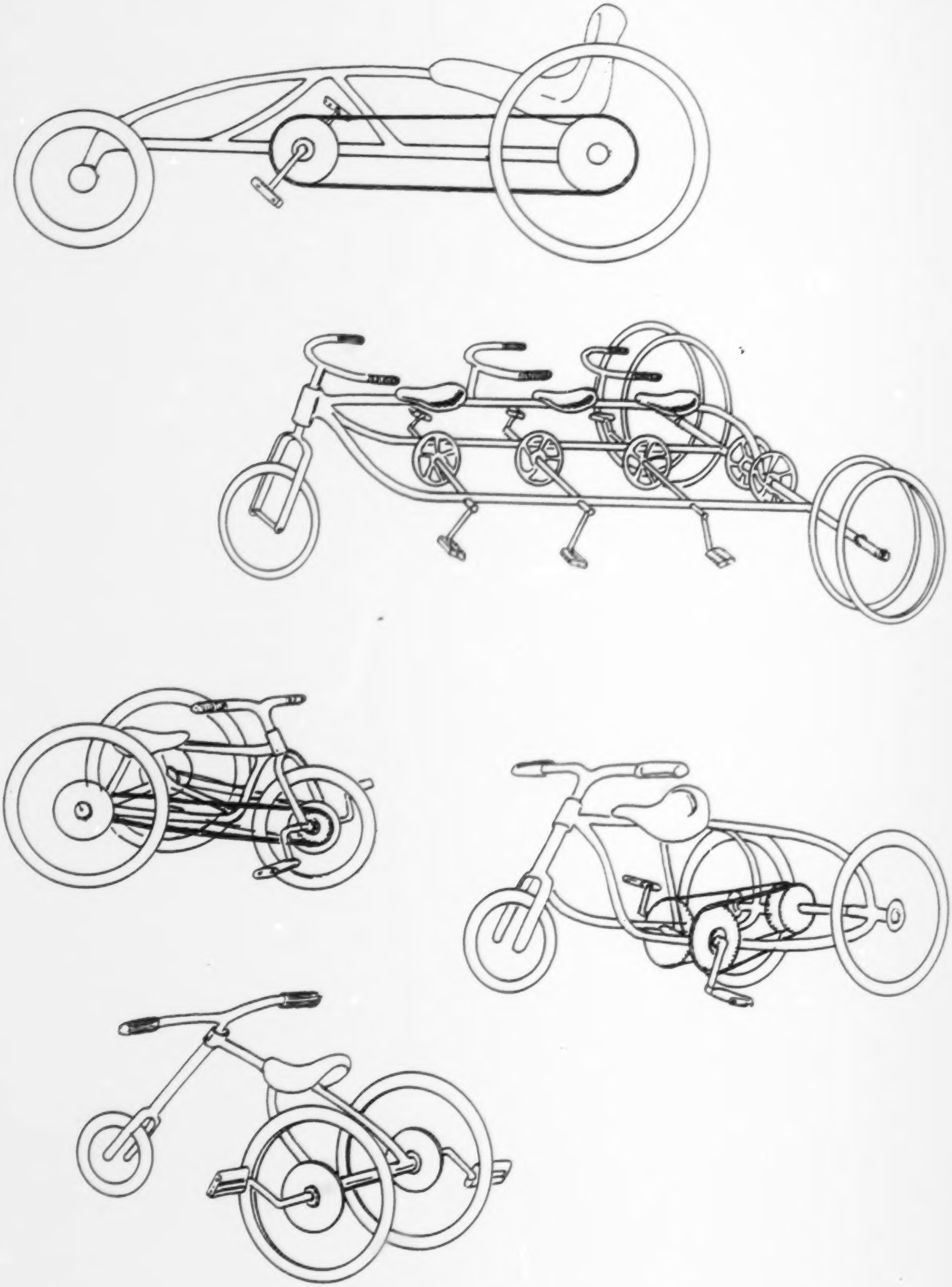


Figure #6 - Graphic Concepts

5. Evaluate the possible solutions and determine which two would be best.
6. Evaluate the two solutions relative to the solution criteria developed in step 8.
7. Decide on the best idea.
8. Prototype the idea and refine it.
9. Build a working vehicle.

TAM #10 - Summary

1. **Review & Summary Activities**

2. **Review Questions -- Test yourself!**
   - A. What is the purpose of a gear?
   - B. What are three types of motion?
   - C. List four of the six kinds of energy that can be converted to power.
   - D. List ways of increasing mechanical advantage.
   - E. What types of mechanisms can be used to transfer energy in non-linear directions?

TAM #10 - Post-assessment

Instructions:

1. Complete the self-check on the activities completed.
2. Have the instructor complete the evaluation and discuss discrepancies between the two assessments.
3. Complete the post-test for TAM #10.
4. If your results demonstrate mastery, go-on to the next TAM or activity assigned by your instructor. If less than completely successful, see your instructor and plan what to do to raise your level of mastery.

TAM #10 - Handout 1

TAM #10 - Problem-solving Observation Form

Session: __________ Class: __________ Group/Ind: __________

Date: __________ Time: __________ Observer: __________

Rate the extent to which the group/individual has implemented each major step of the problem-solving process. Use each step's components as indicators of accomplishment.

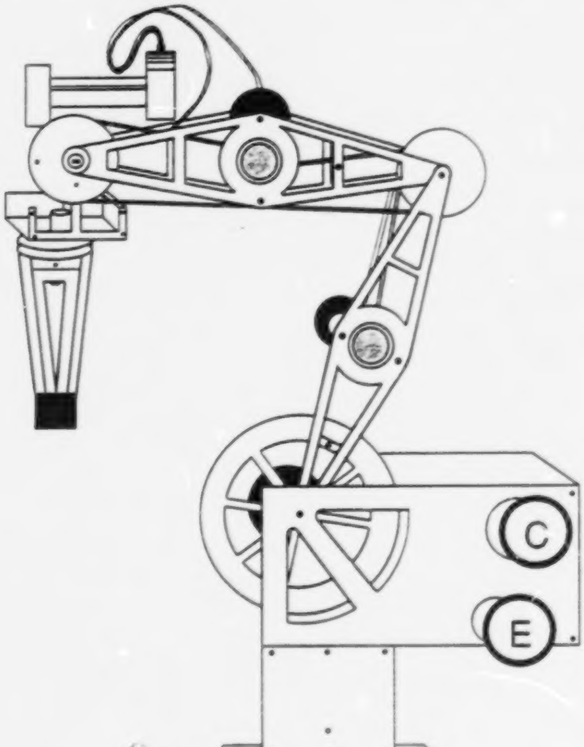
1. **Identify problem**	N/A	Weak	Somewhat	Good	Superior
- Analyze problem	N/A	OK			
- Analyze the problem's context	N/A	OK			
- Define & clarify the problem	N/A	OK			
2. **Establish solution criteria**	N/A	Weak	Somewhat	Good	Superior
- Identify appropriate criteria	N/A	OK			
- Identify constraints and limitations	N/A	OK			
- Weight criteria according to the nature of the problem	N/A	OK			
- Develop a design brief	N/A	OK			
3. **Assemble pertinent information**	N/A	Weak	Somewhat	Good	Superior
- Search for information	N/A	OK			
- Analyze information	N/A	OK			
- Synthesize appropriate information	N/A	OK			
4. **Formulate alternative solutions**	N/A	Weak	Somewhat	Good	Superior
- Brainstorm	N/A	OK			
- Remove barriers to creativity	N/A	OK			
5. **Evaluate alternatives**	N/A	Weak	Somewhat	Good	Superior
- Apply solution criteria	N/A	OK			
- Select optimum solution	N/A	OK			
6. **Implement prototype solution**	N/A	Weak	Somewhat	Good	Superior
- Develop prototype solution - Produce drawings - Test theories	N/A	OK			
- Plan implementation of solution	N/A	OK			
- Implement prototype solution	N/A	OK			
- Evaluate prototype solution in use	N/A	OK			
7. **Refine solution**	N/A	Weak	Somewhat	Good	Superior
- Communicate the solution	N/A	OK			
- Refine the prototype solution	N/A	OK			
- Implement the refined solution	N/A	OK			
- Monitor the solution appropriately	N/A	OK			

Course:	Introduction to Energy & Power Technology

Technology Activity Module #11

Electric Motor Control - Robotics

by: David Roth



TAM #11: Electric Motor Control - Robotics

Instructor Component

Activity Objectives: The purpose of this activity is to familiarize the student with one of the common methods of controlling D.C. motors. These are typically used in automated machines and robotic systems. The student will build an H-network, look at the problems of controlling it, improve on the control, add speed control, and then interface it to an Apple II game port.

Activity Competencies: By completing this TAM, the student will be able to:

1. Construct a circuit that can control a D.C. motor's direction of rotation and speed.
2. Compare and contrast the control problems encountered when using the H-network.
3. Read schematic symbols and correctly identify the component leads used in the circuits.
4. Test the components used in the circuits and determine their condition.
5. Make good electrical connections using proper wiring methods and soldering techniques.
6. Explain what pulse width modulation is and how it is used in controlling a motor.

Module Instructions

Introduction:

The three activities in this TAM should be done in order, beginning with the first activity and moving toward the third. In **Activity 1,** students learn to control a motor forward/reverse and start/stop using two circuit variations. **Activity 2** involves the same circuit as activity one, with the addition of speed control. The speed control circuits and pulse width modulation will be explored. In **Activity 3**, the basic circuit used in activity one will be interfaced to an Apple II computer through the game port. Here the instructor or an advanced student may need to construct an interface cable for the game port. Information is provided regarding how transistors can be used as switches as well as basic knowledge of simple digital electronics. The amount of time needed to complete this TAM can be as short as two weeks or as long as a semester.

Safety Considerations:

- The safe handling of solder and soldering equipment should be reviewed.

- Because this circuit is added to as the student works through the activities, care should be given to disconnecting the circuit from the power source whenever work is in progress. Student injury is not likely, but part damage could occur.
- The use of CMOS I.C. chips and MOSFET transistors require that the handler be at ground potential and static-free. A sudden shot of static can damage these parts.

Needed Materials:

1. Supplies Required

(Note: All of the materials required can be purchased from Radio Shack. However, purchasing these parts mail order can reduce the cost considerably.)

A. 1 - D.C. motor 3 - 12 volts (RS# 273-223)
B. 1 - U_1 4011 quad 2 - input NAND gates (CMOS I.C. chip) (RS #276-2411)
C. Q_1, Q_2, Q_3, Q_4, Q_5 - IRF-511
    1. N-channel power MOSFET transistor (RS #276-2072)
       OR
    2. 4 - NPN power transistors TIP41 or equiv. (RS #276-2017)
       AND
    3. 1-IRF-511 MOSFET
D. D_1 - LED diode (RS #276-041)
E. R_1, R_2, R_3, R_4 - 1 to 3K ohms, 1/4 watt (see text)
F. R_5 - 680 ohms, 1/4 watt (RS #271-021)
G. R_6 - 1K ohms, 1/4 watt (RS #271-023)
H. R_7 - 10K ohm trimmer potentiometer (RS #271-218)
I. R_8, R_9, R_{10}, R_{11} - 4.7K ohm, 1/4 watt (RS# 271-030)
J. R_{12}, R_{13}, R_{14} R_{15} - 680 ohm, 1/4 watt (RS #271-021)
K. R_{16}, R_{16}, R_{18}, R_{19} - 1K ohm, 1/4 watt (RS #271-023)
L. U_2 - 555 timer (RS #276-1723)
M. U_3 - 7404 TTL tex inverter (RS #276-1802)
N. C_1, C_2 - .01 micro farad capacitor (RS #272-1065)
O. U_4, U_5, U_6, U_7 - Opto-isolator (RS #276-139)
P. Solder

2. Equipment/Machines/Tools

A. Soldering pencil (15 to 30 watts) and stand
B. Multimeter
C. Oscilloscope (optional)
D. Logic Probe (optional)
E. Power Supply 0 to 15 volts (optional)
F. Needle nose pliers
G. Diagonal wire cutter

3. Handouts

A. Student Component of TAM #11
B. Handout #1 - Digital electronic components
C. Handout #2 - Apple port setup
D. Handout #3 - Computer Control Program

4. Instructional Resources

A. Catalogs

(Note: Most of these companies will accept a school purchase order once you have established an account. This will speed delivery of material if you call in your order.)

1. Circuit Specialists
P.O. Box 3047
Scottsdale, AZ 85271
(800) 528-1417

2. Jameco Electronics
1355 Shoreway Road
Belmont, CA 94002
(415) 592-8097

3. JDR Microdevices
2233 Branham Lane
San Jose, CA 95124
(800) 538-5000

4. Kelvin Electronics
7 Fairchild Ave.
Plainview, NY 11803
(800) 645-9212

5. Mouser Electronics
P.O. Box 699
Mansfield, TX 76063
(800) 346-6873

B. Books

1. Fowler, Richard J. (1984). Electricity, principals and applications. New York, NY: McGraw-Hill Inc. ISBN 0-07-021707-6
2. McComb, Gordon. (1987). The robot builder's bonanza. Blue Ridge Summit, PA: Tab Books Inc., pp. 97-106 ISBN 0-8306-0800-1
3. Schuler, Charles A. (1984). Electronic, principles and applications. New York, NY: McGraw-Hill Inc. ISBN 0-07--55587-7
4. Vernier, David L. (1988). How to build a better mousetrap and 13 other science projects using the apple II. 97225, 2920 S.W. 89th Avenue. Portland, CA: (503)297-5317. ISBN 0-9183731-16-X

Management/Logistics:

1. Related TAMS

This TAM can be used independently. TAM #2 (Problem Solving) from the Introduction to Materials and Processing Technology Guide provides excellent information which can be used in this TAM.

2. Evaluation/Grading

A. Student-maintained notebook (20% of grade). This should contain the following materials.
   1. Lecture and demonstration notes and drawings
   2. Log entry and report for each days work
   3. Handouts and worksheets

B. Test (30% of grade)

C. Finished projects - see project grade sheet - (40% of grade)

D. Modifying Factors (10% of grade)
   1. Attendance
   2. Attitude
   3. Work habits
   4. Classroom behavior

3. Suggested Schedule/Time

This TAM can be completed in two weeks. However, because of the amount of electronics, the length of time could be extended to cover the theory of operation of the circuits and their components. The amount of time spent on this material depends on the knowledge and background of the instructor.

Key Instructional Suggestions:

1. Safety

Students need to be alerted to the dangers of working with solder and soldering pencils. First, the soldering pencils are quite hot and can cause burns. They can also damage equipment and materials with which they come in contact. Students should be alerted to the dangers of exposure to lead (one of the major elements in solder). Glasses should always be worn when working with solder to prevent solder from splattering into the eyes.

It is important to alert students to the potential damage of static electricity to small electronic circuits and integrated chips. Always work with a ground strap on and turn the power source off whenever making changes or working on a circuit.

2. Motivation

Students may not be aware of how common instrumentation and control devices are in their environment and in industry. You may want to have them brainstorm and develop lists of devices, such as an automobile thermostat, a home thermostat and control unit, a robot arm, an NC mill, and even their bodies (sweating as a cooling response).

Working with electronics may be discouraging to some students if the material is beyond their ability and background. Help them to become familiar with electronically controlled feedback systems by discussing how these devices might be constructed For example, they could conceptualize (black box) a robot feedback and control system without knowing the details of digital logic, principles of sensor construction, etc.

3. Prerequisite Information

This TAM will require that students have some background in basic electronics. Some instructional time will need to be dedicated to such topics as transistors, how motors work, simple digital logic, the operation and testing of diodes, how to solder, how to read schematics, resistor color coding, and construction of an incremental motion controller.

4. Demonstrations

of each activity, circuit operations and test equipment use will need to be demonstrated.

5. Reinforcement

This TAM provides an excellent means for reinforcing some basic principles which students learned in physics, electronics, and computer applications class work. Material from this TAM can also reinforce material presented in discussion of Materials & Processing production systems (e.g. numerical control, computer integrated manufacturing, etc.). Academic skills such as logical thinking, mathematics, and creative problem solving can also be reinforced.

6. Attitudes

Students may become discouraged during construction of the various circuits in these activities. Quite often, wiring mistakes, poor soldering, and misplacement of components can keep the circuits from operating properly. It is at this time that the problem-solving method found in TAM #2 of the Introduction to Materials & Processing Technology Guide should be discussed and used. Nothing can change a student's attitude more than the success of solving his/her own problem with little assistance.

7. Remediation/Enrichment

A. Remediation: Give a student a working unit and allow him or her to do the exercise and write up the comparisons. Allow an advanced student to assist.

B. Enrichment: Challenge this student to come up with a way of using this unit to perform a useful operation, i.e., construct an assembly line, a robotic arm, a gripper, etc. Have an advanced student work with a slower student to get their unit working.

8. Summary & Review

A. The main purpose of solder in electronics work is to make and maintain good electrical connections.

B. In an N.P.N. transistor the base represents the P material and the emitter and collectors represent the N material.

C. In a MOS F.E.T. transistor a charge applied to the gate connection controls the current flowing between the source and drain connection.

D. The three electrodes of an N.P.N. or a P.N.P. transistor are emitter, base, collector.

H. The arrow on the schematic symbol of a transistor, is the emitter.

I. M.O.S. and C.M.O.S. devices must be handled carefully because electrostatic charges can damage them.

J. The reason an opto-coupler is used is to isolate two signal sources from each other.

9. Review Questions & Answers

A. Which one of the following is the best soldering technique?

1. Use the iron to melt fresh solder onto the connection. When the solder cools, heat the connection with the iron to melt the solder again.
2. *Use the iron to heat the connection; use the hot connection to melt the solder.*
3. Use the iron to melt the solder; let the hot solder heat the connection.
4. All of the above.

B. Which one of the following device emits visible light when current flows from cathode to anode?

1. F.E.T.
2. *L.E.D.*
3. Mos F.E.T.
4. S.C.R.
5. Transistor

C. A transistor can be used as a(an):

1. Amplifier.
2. Switch.
3. Resistor.
4. All of the above.
5. *Both 1 and 2.*

10. Other

The cost of a MOFSET transistor is quite high. A good medium duty NPN transistor, such as TIP31 or equivalent, or high-power transistor such as 2N3055 or equivalent, will work well in the H network. The addition of resistors (1K ohm to 3K ohm) to the base of the transistor will help adjust for current and voltage differences of the motor.

Actual construction should be done using the printed circuit board design provided (see page #10 of the Instructor Component). The circuit can be constructed on breadboard; however, students will have a great deal of difficulty doing so.

Date: ________ Class: ________ Name: ________________________

TAM #11: Electric Motor Control - Robotics - Pre-test

Instructions: Place the word or words that correctly completes the sentence in the space provided.

1. A mathematical system that deals with logic relationships and is used to describe the behavior of on-off circuits elements in digital electronics is the ______________________ system.
2. The electrode carrying the primary electron flow on a transistor is termed the ___________________________.
3. A(n) _____________________ is the lead of a transistor shown with the arrowhead on it.
4. A(n) _________________ is a logic circuit of one or more inputs that generates a binary output.
5. The unit of measure of capacitance is a _________________.
6. The abbreviation for a combination of circuit elements on one continuous substrate is ____________.
7. An instrument which combines the functions of a voltmeter, ammeter, and an ohmmeter is called a _________________________.
8. A _________________ logic gate that produces a low output when all inputs are high.
9. An instrument which provides a visual display of what occurs in a circuit is a(n) ____________________________.
10. Semiconductor device used to amplify signals or for switching is called a(n) ___________________________.
11. A ____ is a numeric chart, or table, that describes a number of inputs and shows the outputs corresponding to each input.

Date: ________ Class: ________ Name: __________________________

TAM #11: Electric Motor Control - Robotics - Post-test

Instructions:

1. The N.P.N. and P.N.P transistors are operated with their base-collector junction
   A. Forward-biased.
   B. Reverse-biased.
   C. Bipolar-biased.
   D. Zero-biased.

2. An opto-coupler has what component(s) in its I.C. package?
   A. Light-emitting diode.
   B. Bipolar transistor.
   C. Photodetector
   D. Both 1 and 3

3. A "NAND" gate outputs a logical one
   A. When all inputs are one.
   B. When all inputs are zero.
   C. When one input is one and the other is zero.
   D. Both 2 and 3.

4. The following truth table is what kind of logic gate?

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

   A. AND
   B. OR
   C. NAND
   D. NOR

TAM #11: Electric Motor Control - Robotics - Test Keys

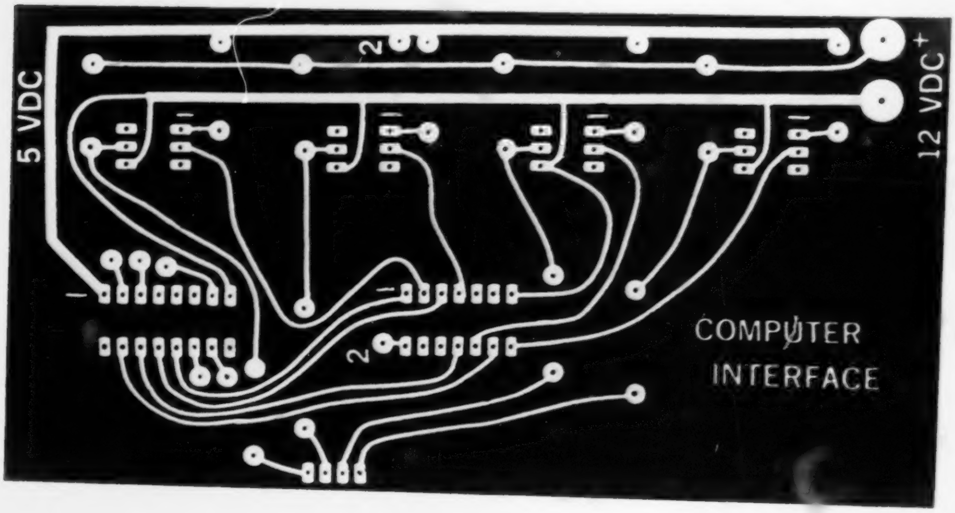
TAM #11- Pre-test Answers

1. Boolean
2. Collector
3. Emitter
4. Encoder
5. Farad
6. IC
7. Multimeter
8. NAND
9. Oscilloscope
10. Transistor
11. Truth table

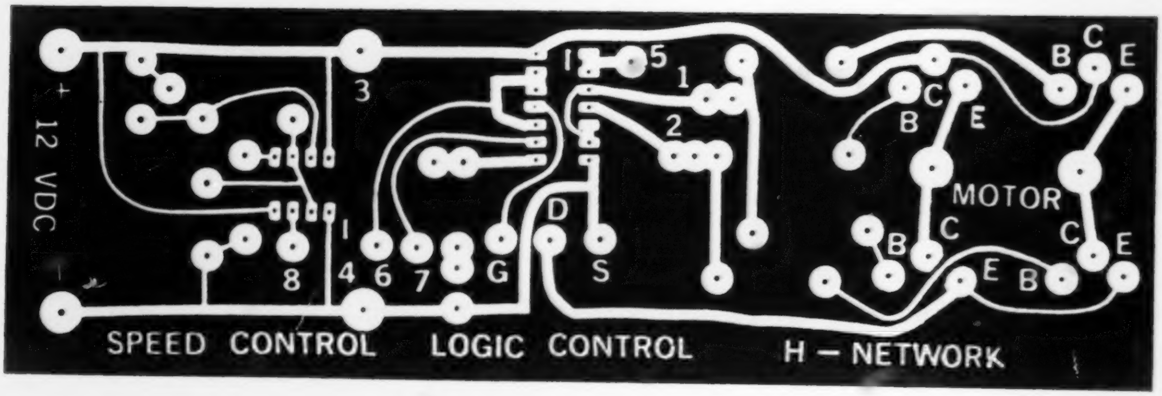
TAM #11- Post-test Answers

1. B 2. D 3. D 4. C

TAM #11: Electric Motor Control - Robotics - PC Board Negatives

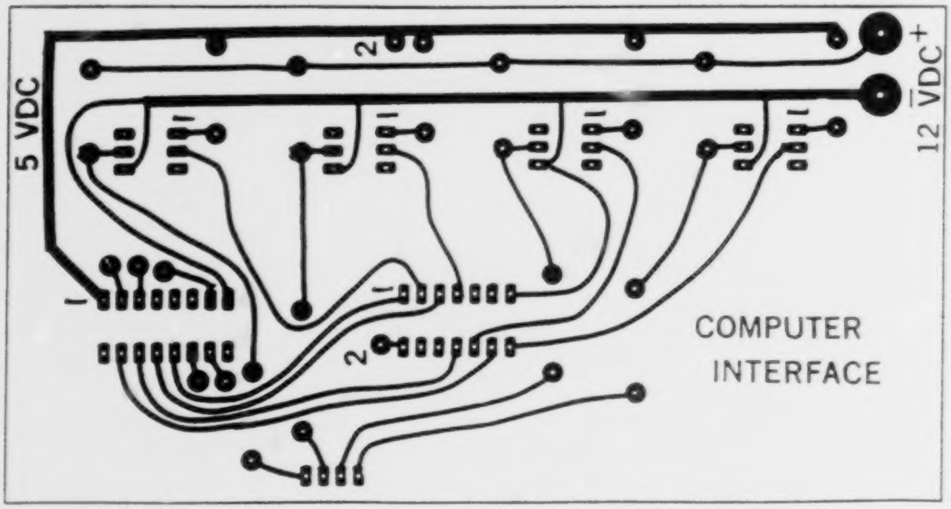

5 VDC
2
12 VDC+
2
COMPUTER INTERFACE

Computer Interface Negative

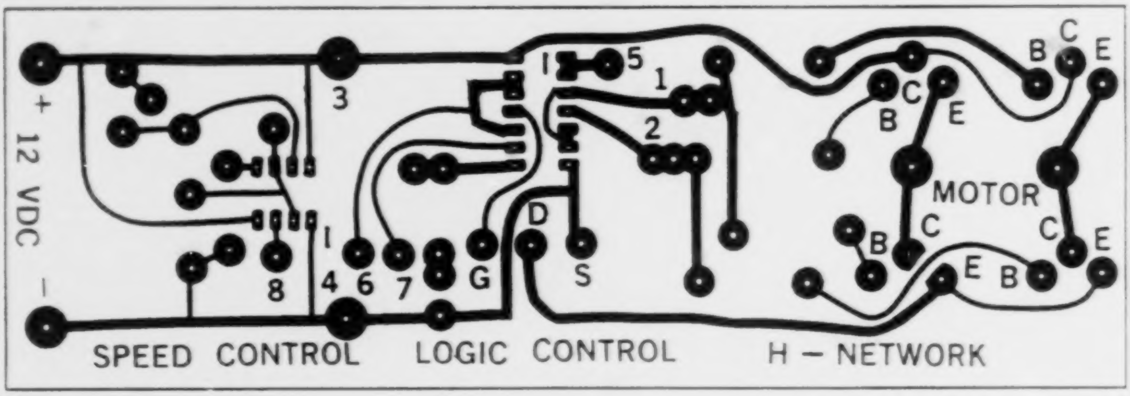

+ 12 VDC −
3
1
5
1
2
B
C
E
B
C
E
MOTOR
D
S
G
1
8
4
6
7
B
C
C
E
B
E
SPEED CONTROL
LOGIC CONTROL
H – NETWORK

Motor Control Unit Negative

TAM #11: Electric Motor Control - Robotics - PC Board Positives


5 VDC
12 VDC
+
−
2
1
1
2
COMPUTER
INTERFACE

Computer Interface Positive


+
12 VDC
−
3
1
5
1
2
8
4
6
7
G
D
S
B
C
E
MOTOR
SPEED CONTROL
LOGIC CONTROL
H – NETWORK

Motor Control Unit Positive

TAM #11: Electric Motor Control - Robotics

Student Component

Introduction:

Did you ever think you could build a robot? It's not as complicated as you might think. In order to build a robot, you will need to understand how to control the motors, solenoids, sensors and other electronic devices that give the robot its movement. Most of the outputs from a computer or other controlling device are 5 volts and very low current. This limits the size and strength of the motor that can be used.

In this TAM, you will learn how to control motors with greater voltage and current ratings. You will study different methods of control and control circuits using digital electronics. You will then connect a motor circuit you have constructed to a computer, and allow the computer to control its performance. Then you will be ready to create your own robotic system.

Competencies: Following the completion of this TAM, you will be able to:

1. Construct a circuit that can control a D.C. motor's direction of rotation and speed.
2. Compare and contrast the control problems encountered when using the H-network.
3. Read schematic symbols and correctly identify the component leads used in the circuits.
4. Test the components used in the circuits and determine their condition.
5. Make good electrical connections using proper wiring methods and soldering techniques.
6. Explain what pulse width modulation is and how it is used in controlling a motor.

Module Overview:

In this TAM you will study the control of a motor using an H-network that you have constructed. This network will control on/off and forward/reverse operation of the motor. In the second activity you will learn about speed control using the popular 555 timer I.C. During the next activity you will interface your H-network with a computer so that the motor can be controlled by a program which the computer executes.

Key Information:

1. Class Presentations

- Motor operation principles
  A. D.C. motors

B. A.C. motor
   1. current
   2. voltage
   3. torque
   4. speed
   5. schematic symbol and reference designation.

- Solid State Theory
  A. Semi-conductor
     1. germanium
     2. silicon

  B. Type of material (N type and P type)
     1. N type
     2. P type

- Diode
  A. Bias
     1. forward
     2. reverse

  B. Types of diodes
     1. silicon
     2. germanium
     3. zener
     4. L.E.D. (Light Emitting Diode)
     5. schematic symbols and reference designation

  C. Ratings
     1. P.I.V. or P.R.V. (Peak Inverse Voltage or Peak Reverse Voltage)
     2. forward current

  D. Testing (ohmmeter and transistor/diode tester)
     1. ohmmeter
     2. transistor/diode tester

- Transistors
  A. Types of transistors
     1. NPN bipolar
     2. PNP bipolar
     3. FET (Field Effect Transistor)
     4. schematic symbol and reference designation

  B. Biasing the junctions and operation
     1. emitter/base junction
     2. base/collector junction

  C. Ratings
     1. current
     2. voltage

  D. Testing transistors (lead identification, junction test with ohmmeter, transistor/diode tester)
     1. lead identification
     2. junction test with ohmmeter
     3. transistor/diode tester

- Digital Circuits
  A. Logic states
    1. high (5 volts)
    2. low (0 volts)

  B. Types of IC
    1. TTL
    2. CMOS

  C. Gates
    1. NAND (the universal gate)
      a. schematic symbol
      b. truth table
      c. boolean expression
    2. AND (optional)
      a. schematic symbol
      b. truth table
      c. boolean expression
    3. OR (optional)
      a. schematic symbol
      b. truth table
      c. boolean expression
    4. NOR
      a. schematic symbol
      b. truth table
      c. boolean expression
      (Note: Know the schematic symbol, truth table, and boolean expression for each.)

- Optical Devices
  A. Photo transistors
  B. Opto-isolator

- Test Equipment
  A. Multimeter
  B. Simple L.E.D.
  C. Transistor/diode tester
  D. Logic probe
  E. Oscilloscope

- Interfacing to computer

2. Demonstrations

- Soldering demonstration
- Demonstration of each activity's circuit operation
- Demonstrate methods of troubleshooting each circuit

3. Safety

- Burn safety
  A. Solder and soldering iron
  B. Overheating of components
  C. Burning circuit board
  D. Hot components after circuit operation

- Electrical safety
  A. Working with power on can damage components
  B. Static can damage parts
    1. CMOS IC chips
    2. MOSFET transistor

Glossary:

1. **Base** -- The region between the emitter and the collector of a transistor; represented by B.
2. **Bias** -- The external voltage applied across the PN junction of a solid state device.
3. **Boolean** -- A mathematical system that deals with logic relationships and is used to describe the behavior of on-off circuits elements in digital electronics.
4. **CMOS** -- Complementary metal oxide semiconductors.
5. **Color code** -- System used to indicate resistance and capacitance. Rings or dots of color mark electronic devices. Values assigned to colors indicate the amount of resistance or capacitance.
6. **Collector** -- The electrode carrying the primary electron flow on a transistor; represented by C.
7. **Emitter** -- The lead of a transistor shown with the arrowhead on it ; represented by E.
8. **Encoder** -- A logic circuit of one or more inputs that generates a binary output.
9. **Farad** -- Unit of measure of capacitance.
10. **FET** -- An abbreviation for a field-effect transistor. A semiconductor device having three terminals: a gate, a source, and a drain. Flow of current is from source to drain with the gate controlling current flow.
11. **Germanium** -- A grayish-white, brittle metallic element; used as a basic semiconductor material.
12. **IC** -- An abbreviation for integrated circuit. A combination of circuit elements on one continuous substrate.
13. **MOFSET** -- Metal oxide semiconductor field effect transistor.
14. **Multimeter** -- A voltmeter, ammeter, and an ohmmeter combined into a single meter.
15. **NAND** -- A logic gate that produces a low output when all inputs are high.
16. **Op-amp** -- An abbreviation for operational amplifier. A very high gain DC amplifier.
17. **Opto-isolator** -- Used to isolate loads from their sources.
18. **Oscilloscope** -- Provides a visual display of what occurs in a circuit.
19. **Peak inverse voltage (PIV)** -- Maximum safe reverse voltage that can be applied to a PN junction.
20. **Reference designation** -- Letter or number that accompanies a schematic symbol to aid in identifying the part.
21. **Schematic** -- An electrical diagram that shows components as symbols and the various places where each connects to another.
22. **Solenoid** -- Coil of wire wrapped around a hollow form, usually with some type of core material sucked into the hollow. Movement of core is used to move a switch or to open valves.
23. **Transistor** -- Semiconductor device used to amplify signals or for switching; derived from transfer resistor.
24. **TTL** -- A type of digital IC chip that uses transistor to transistor logic.
25. **Truth table** -- A numeric chart, or table, that describes a number of inputs and shows the outputs corresponding to each input.
26. **Zener** -- A semiconductor diode that breaks down and conducts current in the reverse direction at a predetermined voltage.

Needed Materials:

1. **Supplies**
   - A. 1 - D.C. motor 3 - 12 volts (RS# 273-223)
   - B. 1 - U_1 4011 quad 2 - input NAND gates (CMOS I.C. chip) (RS #276-2411)
   - C. Q_1, Q_2, Q_3, Q_4, Q_5 - IRF-511
     1. N-channel power MOSFET transistor (RS #276-2072)

        OR
     2. 4 - NPN power transistors TIP41 or equiv. (RS #276-2017)

        AND
     3. 1-IRF-511 MOSFET
   - D. D_1 - LED diode (RS #276-041)
   - E. R_1, R_2, R_3, R_4 - 1 to 3K ohms, 1/4 watt (see text)
   - F. R_5 - 680 ohms, 1/4 watt (RS #271-021)
   - G. R_6 - 1K ohms, 1/4 watt (RS #271-023)
   - H. R_7 - 10K ohm trimmer potentiometer (RS #271-218)
   - I. R_8, R_9, R_{10}, R_{11} - 4.7K ohm, 1/4 watt (RS# 271-030)
   - J. R_{12}, R_{13}, R_{14} R_{15} - 680 ohm, 1/4 watt (RS #271-021)
   - K. R_{16}, R_{16}, R_{18}, R_{19} - 1K ohm, 1/4 watt (RS #271-023)
   - L. U_2 - 555 timer (RS #276-1723)
   - M. U_3 - 7404 TTL tex inverter (RS #276-1802)
   - N. C_1, C_2 - .01 micro farad capacitor (RS #272-1065)
   - O. U_4, U_5, U_6, U_7 - Opto-isolator (RS #276-139)
   - P. Solder
2. **Equipment/Machines/Tools**
   - A. Soldering pencil (15 to 30 watts) and stand
   - B. Multimeter
   - C. Oscilloscope (optional)
   - D. Logic Probe (optional)
   - E. Power Supply 0 to 15 volts (optional)
   - F. Needle nose pliers
   - G. Diagonal wire cutter
3. **Handouts/Instructional Resources**
   - A. Student Component of TAM #11
   - B. Handout #1 - Digital electronic components
   - C. Handout #2 - Apple port setup
   - D. Handout #3 - Computer Control Program

TAM #11: Electric Motor Control - Robotics

Activity #1: H-Network Circuit - Plan of Procedure

1. Construct the H network as found in Figures 1, 2, & 3. For easy construction, the circuit board at the end of the TAM should be made using one of the popular methods for making P.C. boards. Use either the MOSFET transistor (Figure #1) or an NPN bipolar transistor (Figure #2) as suggested by your instructor.

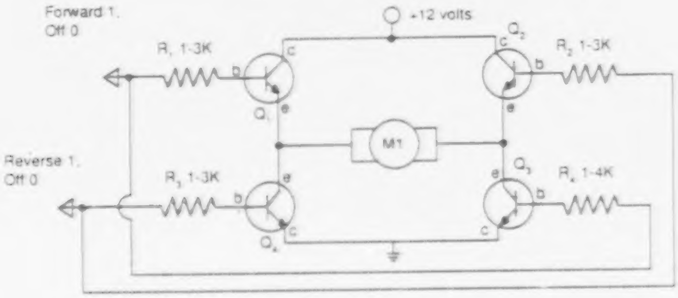

Forward 1, Off 0
Reverse 1, Off 0
+12 volts
R1 1-3K
R2 1-3K
R3 1-3K
R4 1-4K
Q1
Q2
Q3
Q4
M1
b
c
e

Figure #1 - H Network Circuit (MOSFET transistor version)

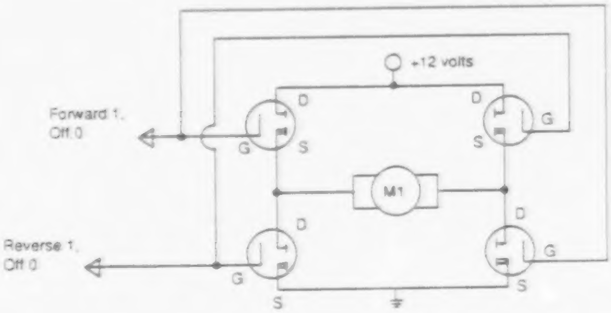

Forward 1, Off 0
Reverse 1, Off 0
+12 volts
M1
D
G
S

Figure #2 - H Network Circuit (NPN bipolar transistor version)

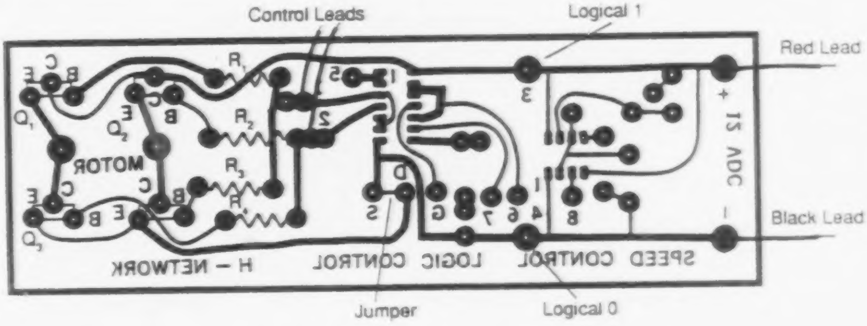

Control Leads
Logical 1
Red Lead
Black Lead
Jumper
Logical 0
Q1
Q2
Q3
R1
R2
R3
R4
MOTOR
H – NETWORK
LOGIC CONTROL
SPEED CONTROL
+ 12 VDC –

Figure #3 - H Network Circuit Diagram

A. Solder resistors R1,2,3,4 onto circuit board in correct location (see diagram 1). Good construction particles require that resistors be installed so that the color code is read in the same direction.

B. Solder jumper lead in holes labeled D and S.

C. Solder red wire to the plus (+) hole and a black wire to the minus (-). These are the wires to which the power supply or the battery will be connected.

D. Solder the transistors into the correct location on the circuit board. Be sure to put the emitter into the hole labeled E, the base in the hole labeled B, and the collector in the hole labeled C. If you have problems with this, refer to Handout #3 for common pin outs of various transistor packages.

E. Use two of the clipped leads from the resistors. Solder one in hole 3 and one in hole 4 of the circuit board.

NOTE: Hole 3 is connected to the positive side of the power source. This becomes the high or logical 1 input point. Hole 4 is connected to the negative side of the power source. This becomes the low or logical 0 input point.

F. Solder into holes 1 and 2 a 5 - 6-inch pieces of wire. These wires become the inputs to the H-network, one being forward rotation of the motor and the other being the reverse rotation of the motor.

G. Solder two 12-inch pieces of stranded wire to the motor terminals. Solder the other ends of the wire into the holes on the circuit board labeled "MOTOR".

2. Connect either a power supply or a 9-volt battery to the circuit. To operate motor, connect input lead 1 to the wire at hole 3. This will apply 12 volts (logical 1 or high) to the H-network and will turn two of the transistors on, thus the motor will turn:

   - clockwise rotation - forward
   - counter-clockwise rotation - reverse

   Next, connect control lead 2 to hole 3. This should change the direction of rotation.

   The following is a truth table. It shows the possible input to the two control lines and their outputs.

Lead 1	Lead 2	Output
0	0	Motor does not run
0	1	Motor runs in one direction
1	0	Motor reverse direction of rotation
1	1	This is prohibited; damage can occur to the circuit

3. If the unit does not function properly, check the following:

   A. Solder connections

      1. Cold solder joints
      2. Lead not completely through circuit board
      3. Solder short or bridge

B. Leads from components correctly identified and properly connected to other components.
C. Make sure correct components have been used.
D. Consult your instructor only after you have checked out these things.

4. Connect a digital multimeter to the motor. Make sure the meter is in the DCV setting and a range setting capable of measuring 12 volts. Operate the motor. Measure and record the polarity and voltage readings obtained from the meter.

   ** **CAUTION** ** These measurements can be made with an analog meter. However, care needs to be taken not to pin the needle of the meter when measuring a voltage of incorrect polarity.

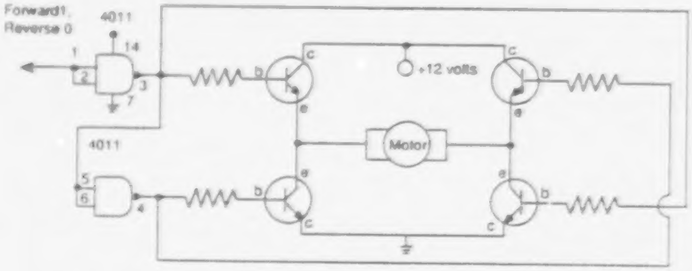
   $V_{forward}$ = ____________ $V_{reverse}$ = ____________

   Discussion:

   The circuit above works great and gives us the control of the direction of rotation. However, the prohibited state (12 volts, logical 1) can cause damage to the circuit and can occur in a real-life application. To overcome this problem, you will add a flip-flop circuit that can control the direction of rotation with only one bit or control line.

5. Disconnect the power source from the circuit.

6. Add the 4011 NAND CMOS gates (U_1) to your circuit as seen in Figures #4 and #5. Be sure that pin 1 on the I.C. is connected to pin 1 of the P.C. board. It is recommended that you install a 14 pin D.I.P socket.


Forward1,
Reverse 0
4011
1
2
14
3
7
4011
5
6
4
b
c
e
+12 volts
Motor
b
c
e
e
c
b
e
c
b

Logic Level

0 = GND or -12 volts - Reverse
1 = +12 volts - Forward

Figure #4 - Adapted H-Network Schematic

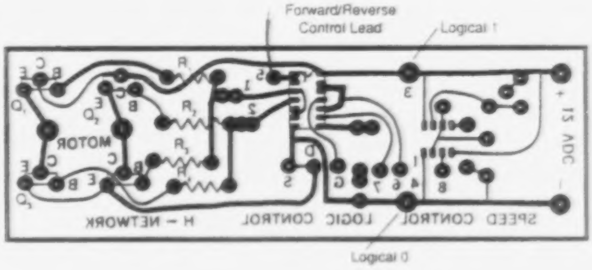

Forward/Reverse
Control Lead
Logical 1
MOTOR
Q1
Q2
Q3
E
C
B
R1
R2
R3
R4
1
2
3
4
5
6
7
8
S
G
D
+ 12 ADC −
H – NETWORK
LOGIC CONTROL
SPEED CONTROL
Logical 0

Figure #5 - Adapted H-Network Circuit

7. Remove the control line from holes 1 and 2 of your circuit board.

8. Solder a control line (piece of stranded wire 5-6 inches long) into hole 5 (which connects to pins 1 and 2 of U_1).

9. Reconnect the power source. The motor should begin running, even if the control lead is not connected to a logic 1 or 0 (point 3 or 12 volts, point 4 or ground-0 volts).

10. Measure and record the amount of voltage and its polarity in the space below.

    $V_{forward}$ = __________ $V_{reverse}$ = __________

11. The control lead is said to be floating when it is not connected to either high or low inputs. The motor is turning (forward/reverse) and the control lead is floating (high/low).

Discussion:

The main problem with this circuit is that there is no way to stop the motor from rotating except to disconnect the power source. In this next section, we will add a MOSFET transistor, which will make and break the ground connection, thus allowing us to start and stop the motor at will.

12. Remove the jumper from the D and S holes on the circuit board.

13. Solder the MOSFET transistor (IRF-511) onto the circuit board (Figures #6 & #7). Make sure that you correctly install the MOSFET, putting the drain lead into the hole labeled D, the gate lead into the hole labeled G, and the source lead into the hole labeled S. HANDLE THIS PART CAREFULLY, as a static charge of electricity can damage the part.

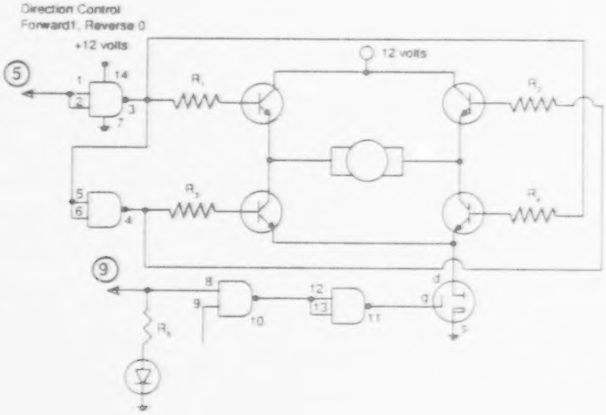


Figure #6 - MOSFET Transistor Added Circuit

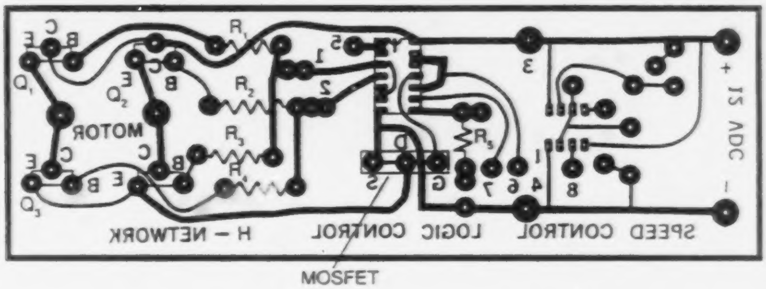


Figure #7 - MOSFET Transistor Added Diagram

14. Install one end of the 330 ohm resistor (R_5) into the hole that connects to pin 8 of U_1 and the other end into the hole next to the gate of the MOSFET.

15. Solder the anode lead of the LED into the hole next to the 330 ohm resistor of last step. The cathode lead of the LED is soldered to ground (or minus) of the power source. The short lead of flat side of the LED is the cathode end.

16. Solder into the holes that connect to pin 8 of U_1 a 5-6 inch piece of wire.

17. Into hole 7, solder a 5-6 inch piece of wire. This hole should connect to pin 9 of U_1.

18. TEST this circuit to see if it is working correctly.
    A. Connect together the two leads from step 16 and 17. Together, they form the start/stop control.
    B. Connect these two leads to the positive side of power source (input logical 1).
    C. The motor should start rotating. If not, connect control lead at hole 5 to positive side of power source (logical 1). The motor should rotate at this time. If not, check the work you have just completed using the procedure in step 3.

19. Complete the truth table below for this circuit.

Input hole 5	Input two leads	Output motor
0	0	
0	1	
1	0	
1	1	

Discussion:

You should have found that the motor only ran when a logical 1 or +12 volts was applied to the two lead inputs. There were only two times when this occurred. One time, the motor turned in one direction, and the other time, it reversed its direction of rotation. Also, note that the two leads are each connected to a separate NAND gate in U_1. We will be using this in the next activity.

TAM #11: Electric Motor Control - Robotics

Activity #2: Speed Circuit - Start Up Overview

In this activity, you will learn about pulse width modulation, a common form of speed control used with motors. Once this principle is understood, you will use it to understand the difference between an open loop system of control and a closed loop system of control.

Pulse width modulation is a method of controlling the speed of a motor by rapidly switching the power supply on and off. The longer the power supply is off, the slower the motor will turn - the longer it is on, the faster it will turn. The circuit used to do this is connected to the ground side of your H-network (Figures #8 and #9).

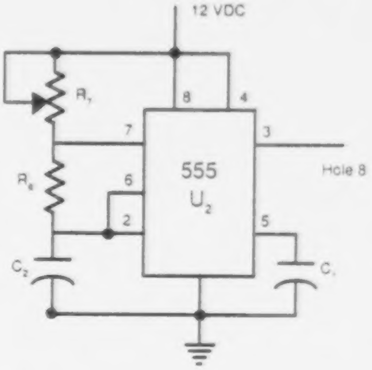

12 VDC
R1
8
4
7
3
555
U2
Hole 8
R6
6
2
5
C2
C1

Figure #8 - Speed Circuit Schematic

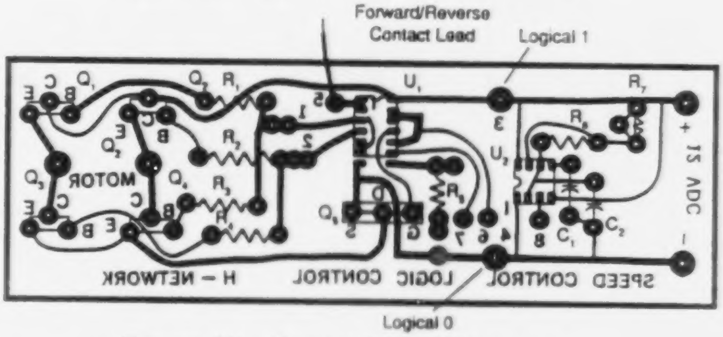

Forward/Reverse Contact Lead
Logical 1
Q1
Q2
Q3
Q4
Q5
R1
R2
R3
R4
R5
R6
R7
U1
U2
C1
C2
MOTOR
+ 12 VDC -
H - NETWORK
LOGIC CONTROL
SPEED CONTROL
Logical 0

Figure #9 - Speed Circuit Diagram

When this pulse width modulation circuit is connected to your H-network, there is no way of knowing if it is controlling the speed of the motor other than the senses (seeing and hearing) of the operator. If, for example, we want a speed of 300 R.P.M., there is no way of setting this and maintaining this speed automatically. This is an example of an open loop system of operation in which there is no way of knowing the speed of operation or even if the motor is turning at all.

In a closed loop system of control, there is a means of detecting these speeds and then controlling them.

Speed Circuit

1. Solder in place an eight pin I.C. socket and install a 555 timer I.C. chip (U_2). Be sure that pin 1 of the I.C. chip lines up with pin 1 on the printed circuit board (see Figures #8 & #9).
2. Solder one end of a 1K ohm resistor (R_6) into the hole that connects pins 7 and 6 of U_2; the other end of the resistor should be soldered into the hole that connects to pin 7 of U_2.
3. Solder one end of a .01 mfd capacitor (C_1) into the hold that connects to pin 2 and 6 and U_2; the other end is connected to the negative side of the power supply.
4. Solder one end of a .01 mfd capacitor (C_2) into the hole that connects to pin 5 of U_2; the other end is connected to the negative side of the power supply.
5. Solder trimmer potentiometer (R_7) into the three remaining holes in the upper left side of the circuit board. The potentiometer (R_7) should connect to pin 7 of U_2 and the positive power source.
6. Solder 5-6 inch pieces of stranded wire to hole 8 that connects to pin 3 of U_2. This is the output of the 555 timer.
7. TEST if you have an oscilloscope or a logic probe. Connect it to the output lead of the 555 timer and minus (ground) and observe the wave form or the pulses. Adjusting the trimmer potentiometer (R_7) should cause this to vary. If you do not have this test equipment, go on to the next step.
8. Remove the lead from hole 7 that connects to pin 9 of U_1.
9. Solder the lead from hole 8 pin 3 of U_2 into hole 7 that connects to pin 9 of U_1.
10. TEST the circuit operation.

Discussion:

The motor should now run when control lead in hole 9, that connects to pin 8 of U_1, is connected to the plus 12 volts or logical 1. The control lead at hole 5 should control the direction of rotation. The speed of the motor should be controlled by turning the trimmer potentiometer. This is also a good example of a closed loop system because there is no circuit to supply feedback to the speed control.

Activity #3: Computer Interfacing of H-Network - Start Up

Overview

In order for any system to be truly robotic or automated, there must be three things present - **a power source** to supply energy to the manipulating device and to the controller, **a device** that is to be controlled (this can be a solenoid, relay, motor, etc.), and **a controller** that will execute a set of instructions to cause whatever action the device is produce. In most cases, this device is a computer. In this activity, you will build an interface that will connect to the 16 pin game port of an Apple II computer. You will then enter a program that will allow you to control the speed, direction of rotation, and on/off functions of the motor. Once you have done this, you are on your way. What type of device can you construct to make use of this system?

Computer Interfacing of H-Network

The interface board can control up to two motors. If you do not wish to control two motors, construct only 1/2 of the circuit (Figure #10).

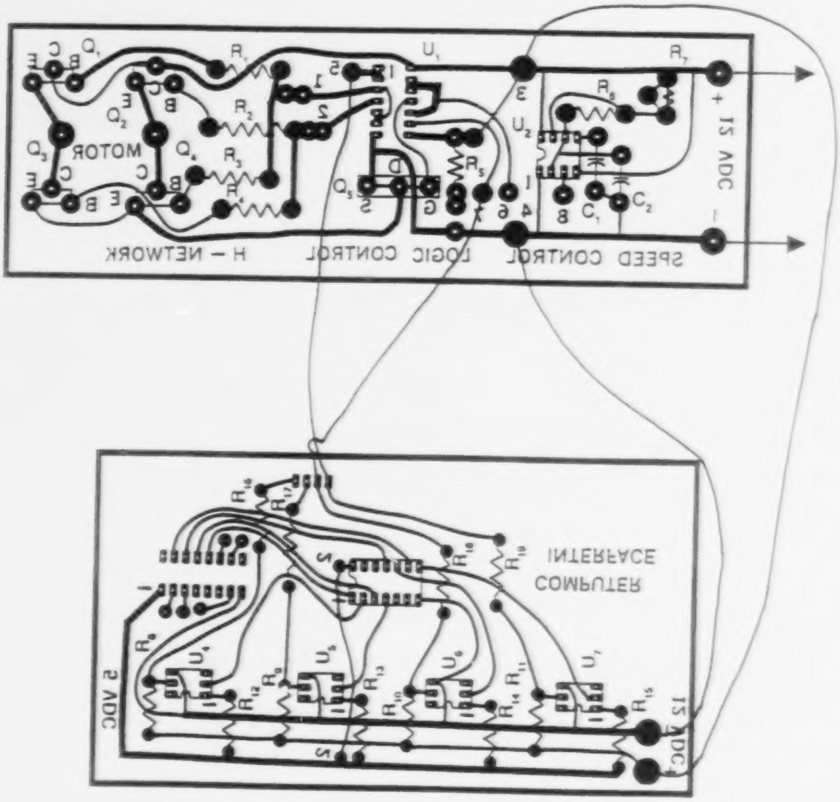

Q1
R1
U1
R7
R8
Q2
R2
U2
Q3
MOTOR
Q4
R3
R5
Q5
R4
C1
C2
12 VDC
+
−
H – NETWORK
LOGIC CONTROL
SPEED CONTROL
R16
R17
R18
R19
COMPUTER INTERFACE
R8
U4
R9
U5
R12
R13
U6
R10
R11
R14
U7
R15
5 VDC
12 VDC

Figure #10 - Connected Boards

1. Make a printed circuit board of the "computer interface" (Figures #10 & #11). Use the pattern supplied and one of the common methods of printed circuit board etching to do this.

2. Solder in place $R_{12, 13, 14, 15}$ (680 ohm) resistors. See Figure #9 for correct location of these parts. Make sure the color code is read the same way for each resistor when it is mounted on the P.C. board.

3. Solder in place $R_{8, 9, 10, 11}$ (4.7K ohm) resistors. See Figure #9 for correct location of these parts. Make sure to install these parts so that the color code on them reads the same way as the resistors previously installed.

4. Solder in place $R_{16, 17, 18, 19}$ (1K ohm) resistors. See Figure #9 for correct location of these parts. Pay attention to how these are installed on the circuit board.

5. Solder in place four 6 pin DIP I.C. sockets. You will install $U_{4, 5, 6, 7}$ (opto-isolator) in these. You may have to make 6 pin sockets by cutting larger sockets down.

6. Solder in place one 16 pin DIP I.C. socket in location P_1. This is where the interface cable from the computer will connect to the interface board. Please take note of where pin number one (1) is located on the P.C. board.

7. Solder in place on 14 pin DIP I.C. socket in location U_3.

8. Solder jumper lead that connects holes 2 on U_3 to hole 2 on the 5-volt line.

9. Solder a red lead to the +12-volt hole and a black lead to the -12-volt hole on the computer interface board. The other end should be connected as follows: red to hole 3 and black to hole 4 of the circuit board in previous activities. You will have to remove a piece of wire from these holes.

10. Connect the on/off control lead (hole 7) from the motor control board to the output pin 3 of the interface board.

11. Connect the forward/reverse control lead (hole 6) from the motor control board to the output pin 4 of the interface board.

12. Connect

13. Remove resistor R_5 from the motor control board.

14. Remove the lead from hole 8, pin 3 of U_2 and solder it in place at hole 3, plus 12 volt.

14. Plug interface cable into P_1 of interface board and the other end into the computer's game port. You will have to remove the cover of your computer and locate this port.

CAUTION: Make sure that pin one of the cable plugs into pin one of the game port and pin one of the interface board. Damage can occur to your computer if this is not done correctly.

15. Turn computer on and type in same program one.
16. Apply power to your motor control board.
17. Run the program.

TAM #11 - Summary

1. **Review & Summary Activities**

   Review the items in the glossary until you can discuss the definitions from memory.

TAM #11 - Post-assessment

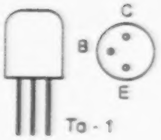
Instructions:

1. Complete the post-test for TAM #11

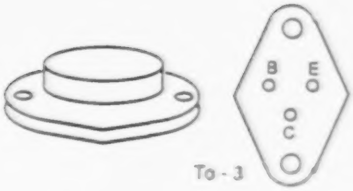
325

TAM #11 - Handout 1

Components

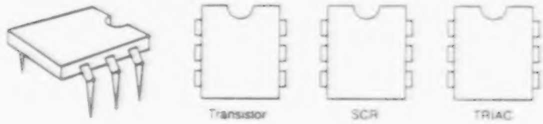


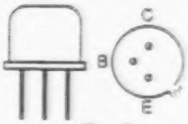
To - 1



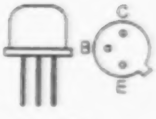
To - 3

OPTO COUPLERS (Deep Subject)

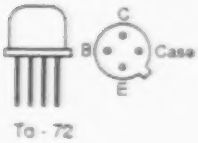

Transistor
SCR
TRIAC



To - 5

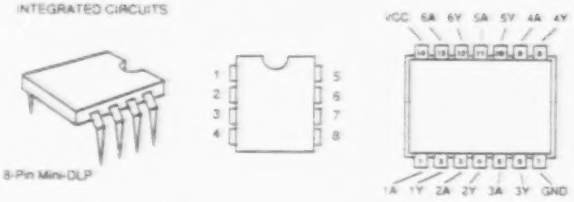


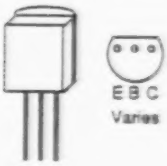
To - 18



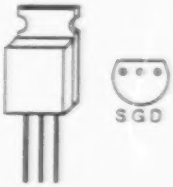
To - 72

INTEGRATED CIRCUITS

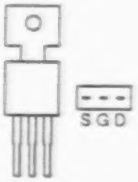

1
2
3
4
5
6
7
8
VCC
6A
6Y
5A
5Y
4A
4Y
1A
1Y
2A
2Y
3A
3Y
GND
8-Pin Mini-DLP



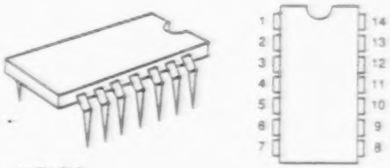
To - 92

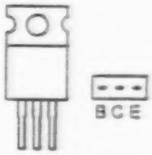


To - 92+

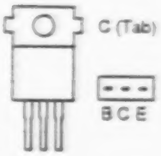


To - 202

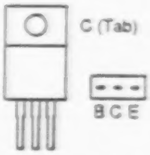

1
2
3
4
5
6
7
14
13
12
11
10
9
8
14-Pin DLP



To - 92

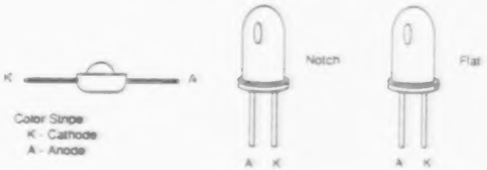


To - 220AB-1



To - 220AB-2

LIGHT EMITTING DIODES


K
A
Color Stripe
K - Cathode
A - Anode
Notch
Flat
A K
A K

C - Collector
B - Base
E - Emitter
S - Source
G - Gate

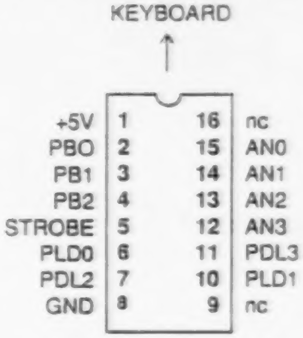
NOTE: Case styles vary and many others are in use. Always consult device specifications to verify pin identification.

TAM #11 - Handout 2

Apple Port Setup

Cables to the Apple Game Ports
16 - Conductor Cables to the Internal Game Port (II+ or II3)

The Apple II+ and IIe both have a 16-pin DIP (Dual In-line Pin) connector inside the computer for use as a game port. To use this connector, you have to remove the top cover of the computer. The connector is in the right rear portion of the computer and looks like an IC socket. The pins and a ribbon cable with a plug to connect to the connector are shown below. Notice that there is a notch on the end of the connector nearest the keyboard. This notch indicates pin #1 of the game port.



INTERNAL GAME PORT

- power supply led (+5 volts DC)
- ground lead (GND)
- switch inputs (PB0, PB1, PB2)
- paddle inputs (PDL0, PDL1, PDL2, PDL3)
- annunciator outputs (AN0, AN1, AN2, AN3)
- strobe output (STROBE)

NOTE: The annunciators are the outputs that are used in this TAM. These outputs are not available on the 9-conductor external game port found on the IIe, IIc, and IIgs.

16-conductor ribbon cable with DIP plugs are sold at most electronic-parts supply houses. If available, purchase a 16-conductor ribbon cable with a DIP plus on both ends. Radio Shack sells a short (18 inch) cable with a plug on each end (RS #276-1976). When using a 16-conductor ribbon cable, mark one corner of the plugs as the #1 pin and always match this pin with the notch on the connector.

It is easy to plug a 16-pin DIP plus in the wrong way. Another potential problem with this kind of connector is bending the pins. The pins are made of very fine wire and can easily bend as you plug them in. Once they bend, they often break when you straighten them out. Worse yet, sometimes you do not notice that the pins have bent instead of making connection, and the circuit will not work. To avoid these problems, make sure all of the pins are straight and in line as you plug in the connector.

TAM #11 - Handout 3

Computer Control Program

```
 10  HOME
 20  REM        EXTERNAL SYSTEMS CONTROLLER
 30  REM        COPYRIGHT 1990
 40  REM        BY TIMOTHY M. BOLLEFER
 41  REM
 50  REM        PERMISSION GRANTED TO ALTER FORM OF PROGRAM
 60  REM        TO SUIT PERSONAL USE AND APPLICATIONS
 70  REM        AS WELL AS MAKE ARCHIVAL COPIES FOR SAME
                PURPOSE
 80  REM        DEFINE VARIABLES
 83  REM        SET VARIABLES TO STARTUP SETTINGS
 85  W = 10:S = 10:D = 1:O = 0
100  B1 = 49420:  REM MOTOR FORWARD
110  B2 = 49241:  REM MOTOR REVERSE
120  A1 = 49242:  REM MOTOR ON
130  A2 = 49243:  REM MOTOR OFF
191  PRINT "External Systems Controller"
192  PRINT : PRINT "Please input desired ranges: "
193  PRINT : PRINT "     Width Variance ";
194  INPUT Q
195  PRINT : PRINT "     Space Variance ";
196  INPUT E
197  PRINT : PRINT 'These are the keys you may':  PRINT "use while
     running:"
198  PRINT : PRINT "W increases pulse width":  PRINT "S increases pulse
     space":  PRINT "A decreases pulse space":  PRINT "Z toggles motor
     direction"
199  PRINT "SPACE turns motor off.  Any key restarts"
200  REM        SYSTEM CONTROLLER
210  REM        INITIAL STARTUP SEGMENT
220  GET C$:  REM  WAIT FOR KEYPRESS
290  REM        FORWARD SEQUENCE
300  POKE B1,0:  REM  FORWARD CODE FOR MOTOR
301  POKE A1,0:  REM  BEGIN PULSE SEQUENCE AND TURN MOTOR
     ON
310  FOR I = 1 TO W:  NEXT I:  REM THIS IS THE PULSE WIDTH
320  POKE A2,0:  REM   END PULSE, PREPARE FOR NEXT STEP
323  FOR I = 1 TO S:  NEXT I:  REM  THIS IS THE PULSE SPACE
330  GOTO 350
340  GOTO 300
350  C = PEEK (  - 16384)
351  POKE - 16368,0
352  IF C > 127 THEN 359
353  GOTO 410
359  C = C - 128
360  IF C = 81 THEN GOTO 2000
361  IF C = 113 THEN GOTO 2000
365  IF C = 119 THEN GOTO 1000
```

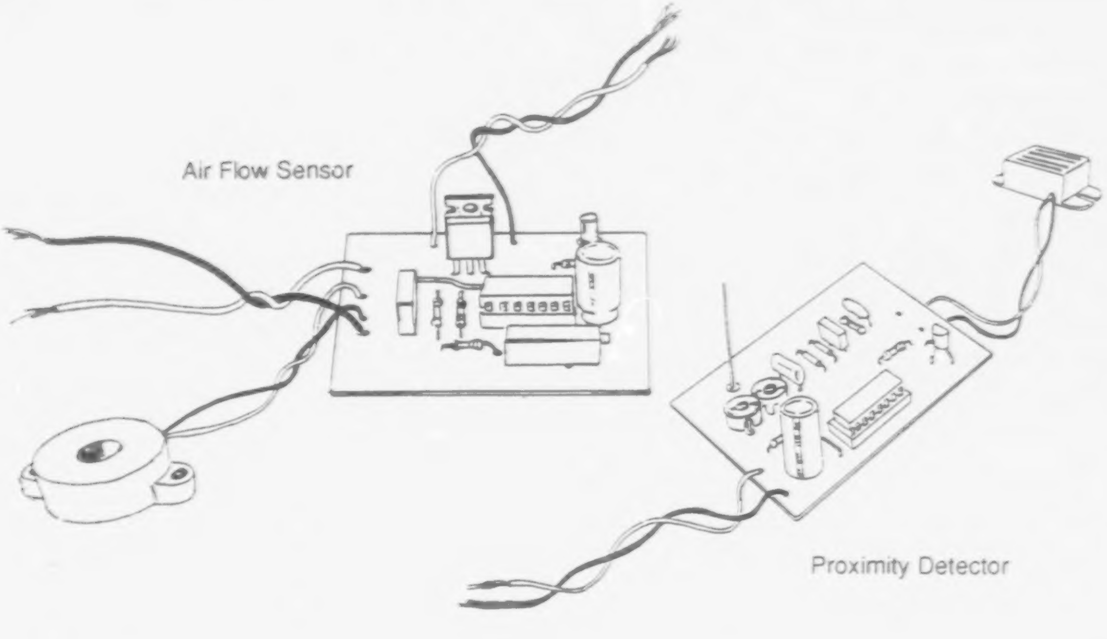
```
  366  IF C = 87 THEN GOTO 1000
  370  IF C = 97 THEN GOTO 2500
  371  IF C = 65 THEN GOTO 2500
  375  IF C = 115 THEN GOTO 1500
  376  IF C = 83 THEN GOTO 1500
  380  IF C = 122 THEN GOTO 3000
  381  IF C = 90 THEN GOTO 3000
  385  IF C = 32 THEN GOTO 20000
  410  IF D = 1 THEN GOTO 500
  420  GOTO 300
  430  GOTO 350
  490  REM        REVERSE SEQUENCE
  500  POKE B2,0:  REM   REVERSE CODE FOR MOTOR
  501  POKE A1,0:  REM   BEGIN PULSE SEQUENCE AND TURN MOTOR
       ON
  510  FOR I = 1 TO W:  NEXT I:  REM  THIS IS THE PULSE WIDTH
  520  POKE A2,0:  REM   END PULSE, PREPARE FOR NEXT STEP
  523  FOR I = 1 TO S:  NEXT I:  REM   THIS IS THE PULSE SPACE
  530  GOTO 350
  540  GOTO 410
 1000  W = W + Q
 1001  REM        INCREASE PULSE WIDTH
 1005  IF W >F 1000 THEN W = 1000
 1010  GOTO 410
 1500  S = S + E
 1501  REM        INCREASE PULSE SPACE
 1505  IF S > 1000 THEN S = 1000
 1510  GOTO 410
 2000  W = W - Q
 2001  REM        DECREASE PULSE WIDTH
 2005  IF W < 0 THEN W = 0
 2010  GOTO 410
 2500  S = S - E
 2501  REM        DECREASE PULSE SPACE
 2505  IF S < 0 THEN S = 0
 2510  GOTO 410
 3000  IF D = 1 THEN GOTO 3020
 3001  REM        CHANGE DIRECTION
 3010  D = 1
 3015  GOTO 410
 3020  D = 2
 3030  GOTO 410
20000  POKE A2,0:  REM   TURN MOTOR OFF
20010  GET KEY$
20011  REM        WAIT FOR KEYPRESS
20020  GOTO 350
```

Course: Introduction to Energy & Power Technology

Technology Activity Module #12

Instrumentation and Control Revealed

by: Lynn Diel


Air Flow Sensor
Proximity Detector

TAM #12: Instrumentation and Control Revealed

Instructor Component

Activity Objectives: The purpose of this activity is to expose the student to the various styles of transducers, sensors, indicators, and controllers.

Activity Competencies: By completing this TAM, the student will be able to:

1. Define basic electrical terminology as it pertains to transducers, sensors, indicators, and controllers.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to transducers, sensors, indicators and controllers.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operations of electric/electronic test equipment and tools.
4. Identify the hazards involved in wiring and installing transducers, sensors, indicators, and controllers.
5. Use electronic components to construct a simple piece of test equipment.
6. Develop problem-solving and creative abilities involving transducers, sensors, indicators, and controllers.
7. Identify the major types of transducers, sensors, indicators and controllers.

Module Instructions

Introduction:

In Activity #1 of the TAM, a student or group of students will construct an air-motion sensor. In activity two of the TAM, a student or group of students will construct a proximity detector.

Safety Considerations:

- Special attention must be given when students use the air-motion detector in working with hot objects or with any type of device that involves circular motion, such as a motor.
- When constructing any of the activities, the student should practice safe and proper work habits, i.e., proper use of hand tools and soldering equipment.

Needed Materials:

1. **Supplies Required**
    A. Parts list for Activity One:
        1. Piezo buzzer (Radio Shack p/n 273-060)
        2. 0.22 uF ceramic capacitor
        3. 1 10 uF tantalum capacitor 16 WVDC

4. 1K Ohm 1/4 watt resistor
5. 100K Ohm 1/4 watt resistor
6. 1 Meg 10 (or 20) turn potentiometer
7. LM324 Operational Amplifier

B. Parts needed for Activity Two:

1. 2 1N914 signal diodes
2. 2 9-50 pF tunable capacitors
3. 680 pF capacitor
4. 0.1 uF capacitor
5. 39 pF capacitor
6. 100 uF capacitor 16WVDC
7. 1K 1/4 watt resistor
8. 5.6K 1/4 watt resistor
9. 100 1/4 watt resistor
10. 4049 inverter
11. buzzer or equivalent

C. Miscellaneous:

1. 330 Ohm 1/4 watt resistor
2. 1 amp SCR P/N: RCA - SK3571 or equivalent

2. Equipment/Machines/Tools

A. Soldering iron (25 watt maximum)
B. 60/40 Rosin core solder
C. 1-3 needle nose pliers
D. Wire cutter
E. VOM or DVM
F. Frequency counter
G. Oscilloscope
H. GFI (Ground Fault Interrupter) for safety
I. ACE Breadboard or equivalent (if not using a PC Board). Printed circuit board (fabricate one from supplied art work).

3. Handouts

Student component of TAM #12

4. Instructional Resources

A. Catalogs

1. Kelvin Electronics
   7 Fairchild Avenue
   Plainview, NY 11803
2. Mouser Electronics
   National Circulation Center
   P.O. Box 699
   Mansfield, TX 76063

B. Books

1. Encyclopedia of electronic circuits, Volume I, by Rudolf F. Graf. TAB Books.

2. Encyclopedia of electronic circuits, Volume II, by Rudolf F. Graf. TAB Books.
3. Linear Data books (e.g., National, Fairchild)
4. CMOS Data books (e.g., National, Fairchild)

Management/Logistics:

1. Related TAMS

This TAM is independent of others.

2. Evaluation/Grading

A. Check sheet.
B. Quality of the finished project.
C. Evaluate pre- and post-test taken by students.

3. Suggested Schedule/Time

The time suggested for this TAM is one to two weeks.

Key Instructional Suggestions:

1. Safety

- Be sure that students are properly informed about the hazards of electrical shock and the potential for burns throughout all activities.
- Be sure that students are properly informed about the hazards of circular motion of fans or motors.

2. Motivation

Due to the nature of the circuit (piezo-electric), the air-motion sensor the capability to not only detect air motion, but it will also detect vibration and/or movement. To entice the students with this circuit, you may want to demonstrate its use as a device to protect a safe or a door to their room. To protect a safe, you will need to mount the piezo-electric sensor to the safe (box) at a point that will give it the most movement. You will need to adjust the potentiometer to set it to a setting that will trigger the LED or alarm relay. Now ask a student to try to open the box without triggering the sensor.

3. Prerequisite Information

Students should have some basic knowledge of electricity/electronics. They should also know how to construct and troubleshoot electronic circuits.

4. Demonstrations

A. Set up proximity detector on the desk or table and ask a student to approach the object without triggering the detector.

B. Set up the air-motion sensor with a relay attached to the output. Connect the relay's contacts to a circuit with a light bulb and a battery. Have student blow on the sensor to see if they can turn the circuit on.

C. The air-motion sensor may be used as a sound-activated switch. You may wish to set up the circuit and have a student clap, whistle, or make some other noise that will cause the device to trip.

5. Reinforcement

This TAM reinforces basic principles of physics.

6. Attitudes

A. General safety attitudes.
B. Housekeeping and general cleanliness.
C. Good circuit construction techniques.

7. Remediation/Enrichment

Remediation: Repeat the initial demonstration. Pair up advanced students with those that are having trouble.
Enrichment: Have students explore the many uses of sensors in industry and the new technology of Programmable Logic Controllers (PLCs).

8. Summary & Review

In this TAM, you will have constructed an experimental air-motion sensor that will allow the student to see a simplified example of a sensor comparable to those used in industry.

In Activity Two, you will see how a simple device, such as a proximity detector, can be used to control equipment that could pose a danger to the personnel working around it (e.g., proximity kill switch for an industrial robot).

Included in the activities is some review of how to construct electronic circuits.

9. Review Questions & Answers

A. A ___________ is an electrical device that converts mechanical energy into electrical. (*Sensor*)

B. A ___________ is an electronic device that converts energy from one form to another. The energy may be electrical, mechanical, acoustical, or other. (*Transducer*)

C. An ___________ is a device or instrument that makes information available but does not store it. (*Indicator*)

D. A ___________ is an instrument which holds a process or condition at a selected level as determined by comparison of the actual value with the set value. (*Controller*)

E. A ___________ device may be used for an indicator as well as a transducer. (*Piezo-electric*)

Date: ________ Class: ________ Name: ____________________________

TAM #12: Instrumentation and Control Revealed: Pre-test

Instructions: Circle the letter that correctly completes the sentence.

1. Indicators allow for:
   A. short-term storage of information.
   B. permanent storage of information.

2. Transducers are used to convert:
   A. electrical energy to mechanical energy.
   B. mechanical energy to electrical energy.
   C. energy from one form to another.

3. Sensors are used to convert:
   A. electrical energy to mechanical energy.
   B. mechanical energy to electrical energy.

4. Controllers are used:
   A. only as interfaces to computers.
   B. to compare a variable state of a device to a fixed or selected state.

Date: ________ **Class:** ________ **Name:** ______________________

TAM #12: Instrumentation and Control Revealed: Post-test

Directions: Evaluate the student by checking the appropriate letter to indicate the degree of competency.

Rating Scale:
^ **Mastered** - has performed task satisfactorily
0 **Not Mastered** - has not performed the task satisfactorily
v **No Exposure** - no experience or knowledge in this area

^ 0 v Identify electrical hazards

^ 0 v Identify and practice shop safety

^ 0 v Identify and practice safe soldering methods

^ 0 v Demonstrate safe and proper use of hand tools

^ 0 v Identify the hazards of rotational devices

^ 0 v Describe the operation of a transducer

^ 0 v List applications for transducers in industry

^ 0 v Demonstrate proper soldering techniques in board construction

^ 0 v Demonstrate proper construction techniques in circuit board construction, i.e., proper component handling

^ 0 v Demonstrate proper breadboarding-techniques in circuit construction

^ 0 v List procedure in calibrating the air-flow sensor

^ 0 v Describe the various operations in which a transducer is used in an industrial setting

^ 0 v Describe the operation of a proximity detector

^ 0 v List applications for a proximity detector in industry

^ 0 v List procedure to calibrate the proximity detector

^ 0 v Perform the calibration of the proximity detector

^ 0 v Describe the various operations in which a proximity detector is used in an industrial setting

TAM #12: Instrumentation and Control Revealed - Test Keys

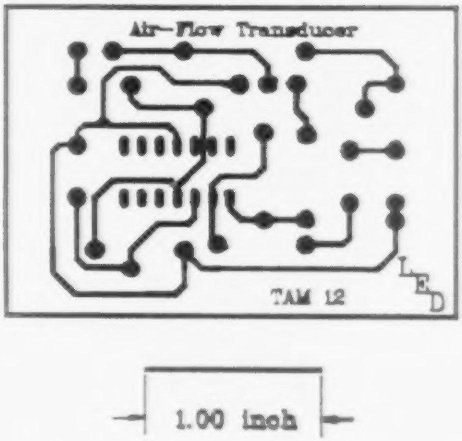
TAM #12 - Pre-test Answers

1. A 2. C 3. B 4. B

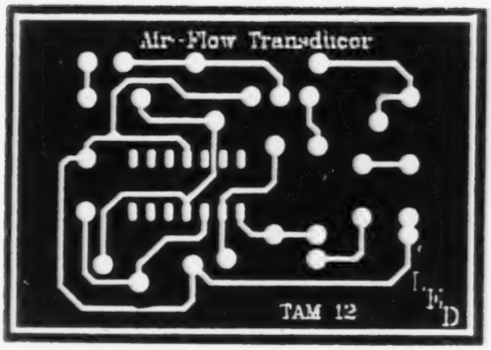
TAM #12 - Post-test Answers

Use rating form

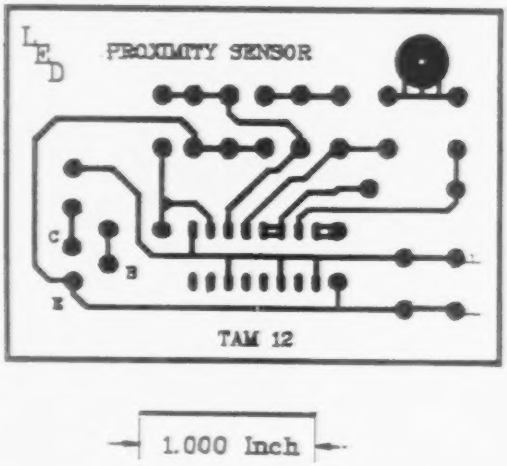
PC Board Artwork


Air-Flow Transducer
TAM 12
L
E
D
1.00 inch

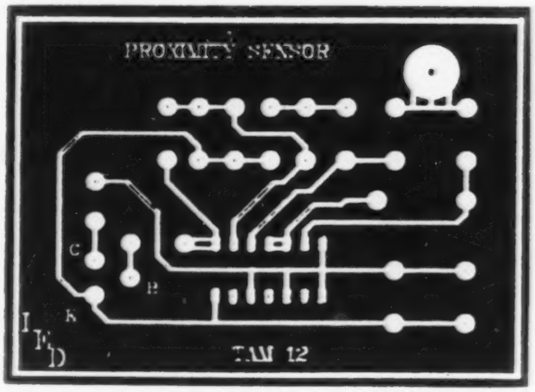
Air Flow Transducer Positive


Air-Flow Transducer
TAM 12
L
E
D

Air Flow Transducer Negative


L
E
D
PROXIMITY SENSOR
C
B
E
TAM 12
1.000 Inch

Proximity Sensor Positive


PROXIMITY SENSOR
C
B
E
L
E
D
TAM 12

Proximity Sensor Negative

TAM #12: Instrumentation and Control Revealed

Student Component

Introduction:

This TAM deals with using electronic instrumentation and controllers. In the first activity, you will build an electronic device which will be capable of detecting air flow or movement. This device may be used for a variety of sensing operations. In the second activity, you will construct an electronic proximity detector. This device is a simplified version of those that can be found in industry. Proximity detectors are used to determine if an object has passed by the detector. They can also be used to protect personnel from coming too close to large industrial robots when the units are in operation.

Competencies: Following the completion of this TAM, you will be able to:

1. Define basic electrical terminology as it pertains to control and instrumentation.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to controllers and instrumentation.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operations of electric/electronic test equipment and tools.
4. Identify the hazards involved in connecting instrumentation to equipment.
5. Use electronic components to construct a series of simple test equipment.
6. Differentiate between the various devices (i.e., indicators, sensors, detectors, controllers).
7. Explain how a transducer can convert energy from one form to another.
8. Differentiate between direct and remote connections of test equipment.

Module Overview:

This module contains the following two activities:

1. Air movement sensor construction
2. Proximity detector construction

Activity Sequence:

1. Participate in the instructor's demonstration for this TAM. Follow all instructions, e.g., reading the assigned material and reviewing the procedural steps.
2. Complete the pre-test given by the instructor.
3. Do Activity #1 - Constructing the air movement sensor.
4. Do Activity #2 - Constructing the proximity detector.

5. Review the material and summarize in your own words.
6. Complete the post-assessment procedure.

Key Information:

1. Class Presentations

- How a transducer converts energy.
- The importance of electronic control and instrumentation.
- The variety of electronic controls and instrumentation.
- Identify some uses for electronic instrumentation.

2. Demonstrations

- Soldering techniques.
- Using an air motion sensor.
- Using a proximity detector.

3. Safety

- Devices with circular motion.
- Proper hand tools usage.
- Electric shock.
- Handling hot items.
- Proper soldering techniques.
- Special attention must be given when students work with any type of device that involves circular motion, such as a fan.
- When constructing either of the activities, the student should practice safe and proper work habits, i.e., proper use of hand tools and soldering equipment.

4. Personal Activity

As your homework, you should research local industrial manufacturers to see how and where electronic instrumentation is used.

Alternatively, visit a local manufacturing plant or other industrial plant and discuss the various uses for sensors, detectors, indicators. You will also want to think about the role that PLCs (Programmable Logic Controllers) are playing in automating industry.

In Activity #1 of the TAM, a student or group of students will construct a device to detect air motion. You will learn how to calibrate and use this instrument. In Activity #2 of this TAM, you will have a chance to construct a device that will sense if one object is close to another one.

Glossary:

1. **Calibrate** -- To standardize a measuring instrument in order to determine or mark graduations.
2. **Controller** -- An instrument that holds a process at a set level as determined by a comparison of the actual value to the set value.
3. **Diode** -- A solid state device usually designed to permit electron flow in one direction and block flow from the other direction.
4. **Indicator** -- A device that allows for short-term storage of information.
5. **Negative** -- A reversed photographic image which may be used in making pc boards.
6. **Operational Amplifier (op amp)** -- High-gain amplifier with negative feedback, commonly used in linear IC chips and a A/D converters.
7. **Piezo-electric Device** -- A substance that generates an electric voltage when distorted by bending, twisting, squeezing, or other means. Conversely, when voltage is applied, it will twist, bend, expand, contract, or distort in some form.
8. **Potentiometer** -- A variable resistor connected as a series voltage divider.
9. **Sensor** -- A device that converts mechanical energy to electrical energy.
10. **Transducer** -- A device that converts energy from one form to another form of energy (i.e., electrical to mechanical and vice versa).

Needed Materials:

1. **Supplies Required**
   A. Parts list for Activity One:
      1. Piezo buzzer (Radio Shack p/n 273-060)
      2. 0.22 uF ceramic capacitor
      3. 10 uF tantalum capacitor 16 WVDC
      4. 1K Ohm 1/4 watt resistor
      5. 100K Ohm 1/4 watt resistor
      6. 1 Meg 10 (or 20) turn potentiometer
      7. LM324 Operational Amplifier

   B. Parts needed for Activity Two:
      1. 2 1N914 signal diodes
      2. 2 9-50 pF tunable capacitors
      3. 680 pF capacitor
      4. 0.1 uF capacitor
      5. 39 pF capacitor
      6. 100 uF capacitor 16WVDC
      7. 1K 1/4 watt resistor
      8. 5.6K 1/4 watt resistor
      9. 100 1/4 watt resistor
      10. 4049 inverter
      11. Buzzer or equivalent

   C. Miscellaneous:
      1. 330 Ohm 1/4 watt resistor
      2. 1 amp SCR P/N

2. **Equipment/Machines/Tools**
   A. Soldering iron (25 watt maximum)
   B. 60/40 Rosin core solder
   C. 1-3 needle nose pliers
   D. Wire cutter
   E. VOM or DVM
   F. Frequency counter
   G. Oscilloscope
   H. GFI (Ground Fault Interrupter) for safety
   I. ACE Breadboard or equivalent (if not using a PC Board). Printed circuit board (fabricate one from supplied art work).

3. **Handouts**

   Student component of TAM #12

TAM #12: Instrumentation and Control Revealed

Activity #1: Air Flow Sensor - Plan of Procedure

1. Construct the following circuit (Figure #1) either on breadboard or on a printed circuit board. For the printed circuit board, see accompanying handout.

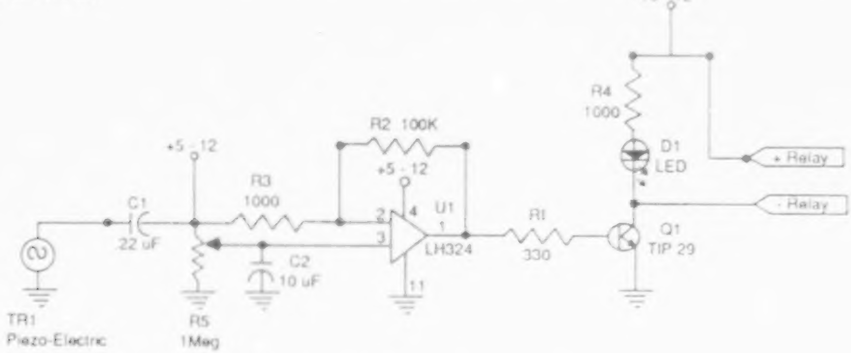

+5 - 12
R4
1000
D1
LED
+ Relay
- Relay
R2 100K
+5 - 12
+5 - 12
R3
1000
C1
22 uF
U1
2
4
3
1
LH324
11
R1
330
Q1
TIP 29
C2
10 uF
TR1
Piezo-Electric
R5
1Meg

Figure #1 - Air Flow Sensor Schematic

2. Construct the air-motion sensor as shown below (Figure #2).

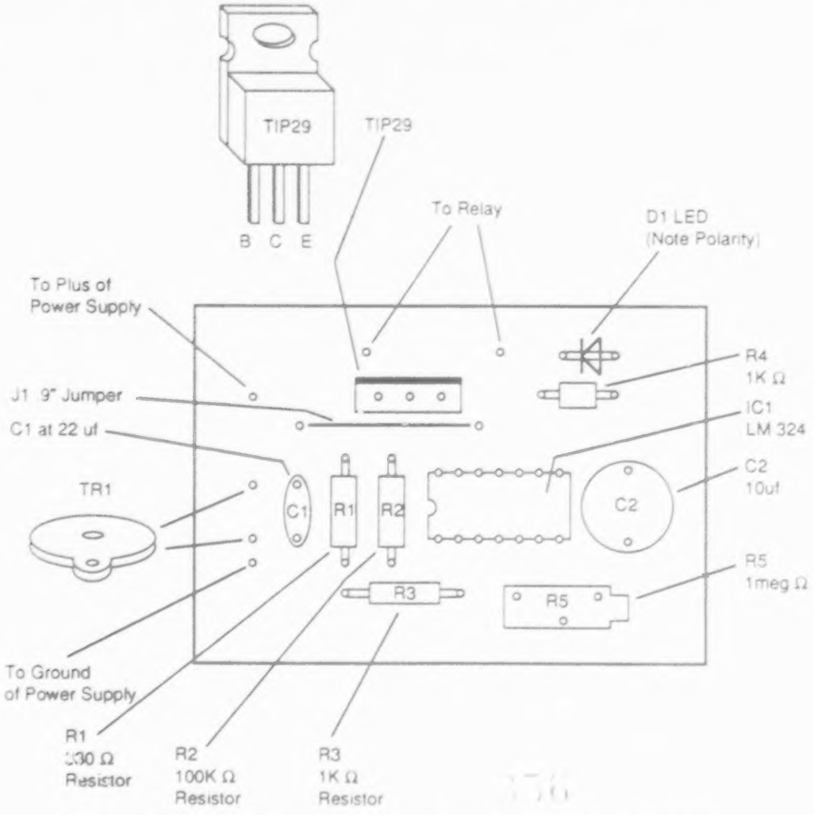

TIP29
B C E
TIP29
To Relay
D1 LED
(Note Polarity)
To Plus of
Power Supply
R4
1K Ω
J1 .9" Jumper
IC1
LM 324
C1 at 22 uf
C2
10uf
TR1
C1
R1
R2
C2
R3
R5
R5
1meg Ω
To Ground
of Power Supply
R1
330 Ω
Resistor
R2
100K Ω
Resistor
R3
1K Ω
Resistor

Figure #2 - Air Flow Sensor Parts Placement Diagram

3. Check Out and Calibration
   - A. Turn on the power supply and adjust the voltage to 9 volts DC.
   - B. Turn off the power supply for now.
   - C. Connect the ground lead of the air-motion sensor to the ground lead of the power supply.
   - D. Connect the power lead of the air-motion sensor to the power lead of the power supply.
   - E. Adjust R5 to the middle of its rotation.
   - F. Turn the power supply on.
   - G. Adjust the potentiometer (R5) so that the LED just comes on, then reverse one-half turn.
   - H. Now blow lightly on the piezo-electric sensor, the LED should come on. To decrease the sensitivity, adjust the potentiometer so it takes an increased amount of air to trigger.

4. Industry depends on sensors, transducers, sensors, indicators and controllers to help maintain its high volume output of goods and services. One such device is the simple transducer. A transducer is a device that is capable of converting one form of energy into another, such as taking mechanical energy and converting it into electrical energy. The unique aspect of transducers is that they can work both ways. The simple air-motion device you constructed in Activity One is based upon the transducer effect. By connecting the transducer to the Op-Amp (operational amplifier), we could take the mechanical energy (air movement against the sensor) and convert it to electrical energy. By allowing the air to strike the transducer, we can then make use of the piezo-electric effect of the device. A similar device is used in industry to detect the air motion surrounding a critical HVAC (Heating, Ventilation, and Air-Conditioning) unit. Another area in which this type of device could be found in is the production area of a robot-controlled paint sprayer at an automobile manufacturing plant.

   Due to the uniqueness of the circuit, you could connect the transducer to a solid object (i.e., table, desk, etc.) and use the transducer as a motion sensor. A similar device is used in industry to indicate if an operation is generating too much motion. A good example in everyday use around your home is a simple motion sensor in your washing machine, which is used to indicate if the load is off-balance.

TAM #12: Instrumentation and Control Revealed

Activity #2: Proximity Detector - Plan of Procedure

1. Construct the following circuit (Figure #3) either on breadboard or on a printed circuit board. For the printed circuit board, see accompanying handout.

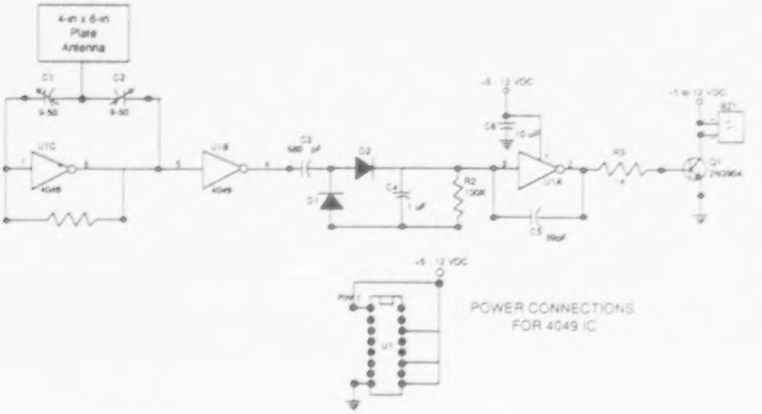

4-in x 6-in
Plate
Antenna
C1
C2
9-50
9-50
U1C
4049
U1B
4049
C3
680 pf
D2
D1
C4
1 uf
R2
100K
+5 - 12 VDC
C6
10 uf
U1A
C5
39pF
R3
1k
+5 to 12 VDC
BZ1
Q1
2N3904
+5 - 12 VDC
PIN 1
U1
POWER CONNECTIONS
FOR 4049 IC

Figure #3 - Proximity Detector Schematic

2. Construct the proximity detector as shown below (Figure #4).

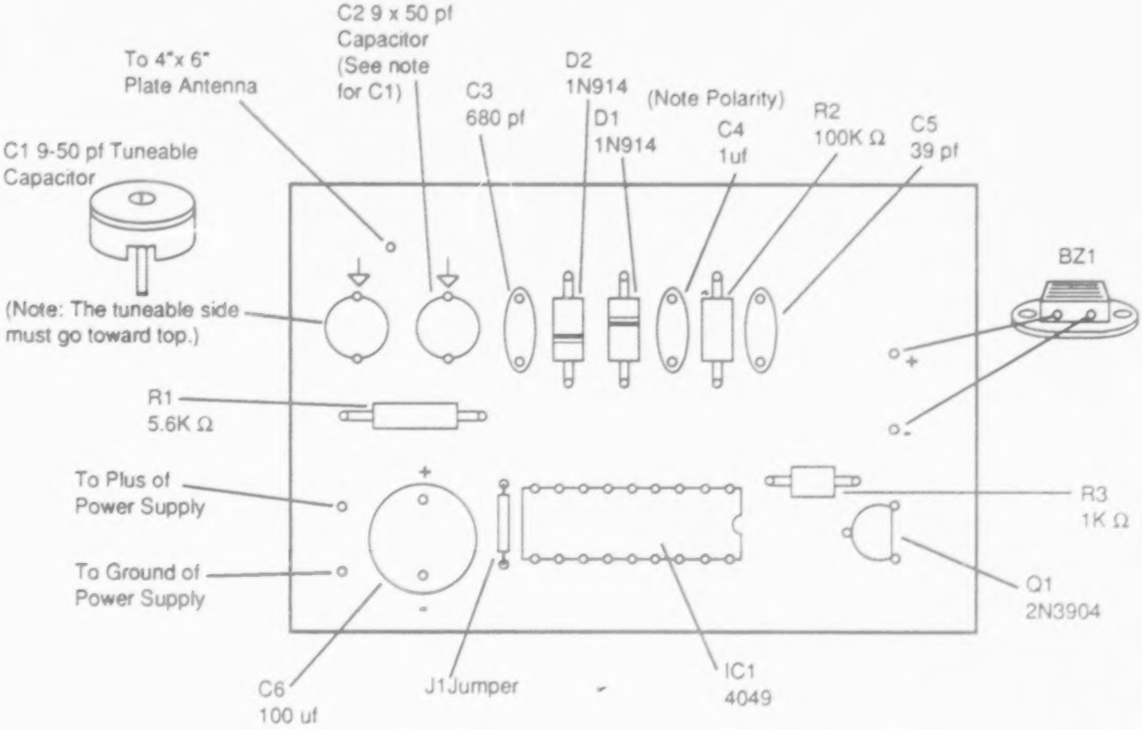

C2 9 x 50 pf
Capacitor
(See note
for C1)
To 4"x 6"
Plate Antenna
D2
1N914
C3
680 pf
(Note Polarity)
D1
1N914
C4
1uf
R2
100K Ω
C5
39 pf
C1 9-50 pf Tuneable
Capacitor
(Note: The tuneable side
must go toward top.)
BZ1
+
-
R1
5.6K Ω
To Plus of
Power Supply
To Ground of
Power Supply
+
-
R3
1K Ω
Q1
2N3904
C6
100 uf
J1Jumper
IC1
4049

Figure #4 - Proximity Detector Parts Placement Diagram

3. Check Out and Calibration
   A. Turn on the power supply and adjust the voltage to 9 volts DC.
   B. Turn off the power supply for now.
   C. Connect the ground lead of the proximity detector to the ground lead of the power supply. Connect the power lead of the proximity detector to the power lead of the power supply.
   D. Adjust C1 to the middle of its rotation.
   E. Adjust C2 to the middle of its rotation.
   F. NOTE: You may wish to disconnect the buzzer from the circuit until the calibration has been completed to reduce the noise level.
   G. Connect the 4 x 6 inch aluminum or equivalent pickup device to the proximity detector. NOTE: To aid calibration, allow at least 12 inches, but not more than 18 inches, between the proximity printed circuit board and the pickup device.
   H. Connect an oscilloscope lead to pin 4 of the 4049 (U1).
   I. Connect the ground of the oscilloscope to the ground of the power supply.
   J. Turn on the power supply.
   K. Adjust C1 until the signal is at its smallest amplitude.
   L. Adjust C2 until the signal is at its smallest amplitude or completely stops oscillation.

   NOTE: If you are unable to stop the oscillation, then turn the power supply down until the circuit stops oscillating (this should happen around 5 to 6 volts).

   M. Now turn C1 a little (either direction) until the oscillation starts again.
   N. Now move your hand towards the pickup device. The buzzer should sound and the LED should light.
   O. By fine-tuning the adjustment of C1 and C2, you should be able to detect a normal size hand parallel to the pickup at 1 to 5 inches.

4. Industry uses proximity detectors in many areas. One such area is that of operator safety. Due to the speed and force at which an industrial robot operates, safety engineers use proximity detectors in conjunction with several devices that will shut down a robot arm or manipulator instantaneously if an operator comes within harm's way. In another area, proximity detectors are used to count sensitive components that pass by the sensor, such as gold-plated contacts of electronic headers. They are also used to detect a missing product from a failed operation, such as a loaf of bread failing to make the transfer from the slicer to the bagging operation. Proximity detectors are heavily used wherever the detection device must not come in contact with the device.

TAM #12 - Summary

The area of instrumentation and control has grown from meager beginnings to a multi-billion dollar per year business. Industry will increasingly require its operators to learn more about these devices. The technology of electronic instrumentation and control has been rapidly increasing, with a strong emphasis on computerization. In addition, industry has started to switch to Programmed Logic Controllers (PLC), which will allow the operation of the plant to be modified as the need arises without major changes in the equipment. Industry will be seeking competent and self-motivated personnel to help it compete in the world markets.

TAM #12 - Post-assessment

Instructions:

1. Complete the post-test for TAM #12.
2. Have the instructor check your circuits for proper operation.

Course:	Introduction to Energy & Power Technology

Technology Activity Module #13

Energy Audits

by: Alice Mohr

TAM #13: Energy Audits

Instructor Component

Activity Objectives: The purpose of this activity is to develop student understanding of energy, its sources, uses, associated costs and the impact of continued usage at current rates. Student activities will include conducting a home energy audit and a study of personal energy consumption for a twenty-four hour period. Recognizing and responding to the need for energy conservation will be emphasized.

Activity Competencies: By completing this TAM, the student will be able to:

1. Define and explain technical terms related to the study of home and personal usage of energy.
2. Identify and describe limited, unlimited and renewable sources of energy in the world, in the U.S.A., and in Missouri.
3. Employ a systematic process to audit the use of energy.
4. Describe various home weatherization measures, citing the characteristics, advantages, and cost effectiveness of each.
5. Demonstrate the safe and proper use of energy weatherization tools, equipment, materials and processes.
6. Select and install an energy conservation measure.
7. Employ individual and group problem-solving processes to analyze data and graphically display results.
8. Recognize and respond to the need for energy conservation in residential, commercial, industrial and transportation applications.
9. Identify and evaluate the merits of various energy conservation measures for home/industry.

Module Instructions

Introduction:

This activity is designed for students to survey their energy usage and to project the cost of that energy. After learning about methods and impacts of energy conservation, students will be able to identify, recommend and implement energy conservation measures. This TAM includes a home energy audit, a personal energy survey, home weatherization activities and an exercise in future projecting.

Safety Considerations:

- Show students how to safely use a ladder before they start measuring for the home audit.

- The usual safety rules for the use of the tools, equipment, materials and processes should be followed in taking energy conservation measures.
- If fiberglass or other insulation is used, the safety guidelines provided with that particular material must be followed.
- Manufacturer's liability for insulation materials should be noted.

Needed Materials:

1. **Supplies Required**
    - A. Activity 1
        1. 3" x 5" cards
        2. Construction paper or poster board
        3. Rubber cement
        4. Compass
        5. Protractor
        6. Scissors
    - B. Activity 2

      Insulation materials (such as those used for weatherstripping, caulking, plastic sheeting, fiberglass batting, tape)
2. **Equipment/Machines/Tools**
    - A. Caulking gun
    - B. Stapler
    - C. Basic woodworking tools
    - D. Gloves
    - E. Computer (optional)
    - F. Calculator
3. **Handouts**
    - A. Student component of TAM #13
    - B. Home Energy Audit
    - C. Energy Usage Chart
4. **Instructional Resources**
    - A. Catalogs (construction equipment & materials)
        1. Missouri Department of Natural Resources, Division of Energy. (n.d.). Free energy publications. Jefferson City, MO: Author.
    - B. Books
        1. Hacker, M. & Barden, R. (1988). Living with technology (pp. 383-403). Albany, NY: Delmar Publishers.
        2. Landers, J. (1986). Home repair and maintenance (pp. 319-331). South Holland, IL: Goodheart-Willcox.
        3. Missouri Department of Natural Resources. (n.d.). The Missouri energy management handbook for homeowners. Jefferson City, MO: Author.
        4. Todd, R. McCrory, D. & Todd, K. (1985). Understanding and using technology (pp. 359-376). Worchester, MA: Davis Publications.
        5. Teaching about energy (Vol. 3), (pp. 7-3 to 7-77). Santa Monica, CA: Enterprize for Education, Inc.

6. Missouri Department of Natural Resources. (n.d.). (Pamphlets available from the Missouri Department of Natural Resources, Jefferson City, MO).
   - QUEST -- Home Energy Analysis
   - Automatic Thermostat Control Timer
   - Energy Cost Comparison Chart
   - Energy Facts: Prices Since 1979
   - How to Insulate Your Home Yourself
   - Get More Missouri per Gallon
   - Solar Energy and Your Home: Questions and Answers
   - Wind Energy
   - SHO-ME Hot Water
   - Waterbed Energy Savings
   - Earth Sheltered Houses
   - Shading Devices
   - Passive Solar Heating
   - Types of Caulking Comparison Chart

C. Film slides/film/video

1. A wide variety are available from Union Electric for their service area. Check with your local utility company.
2. The DNR Division of Energy, Energy Information Clearinghouse, P.O. Box 176, Jefferson City, Missouri has 25 films on energy, plus filmstrips and videotapes, all loaned at no charge.

D. Computer software

1. Home Energy Conservation. Two-part program involves students in analyzing and improving energy usage. Megatech, 29 Cook St., Bellerica, Massachusetts.
2. Personal Energy Inventory. Audits family's use of energy and compares it with others and national averages. HRM Software, 175 Tompkins Ave., Pleasantville, New York.

Management/Logistics:

1. Related TAMS

This TAM provides provides solid background for TAM #1 - Energy Odessy and TAM #16 - Power Distribution Model.

2. Evaluation/Grading

Assess student's performance on :

A. Thoroughness of home audit.
B. Completion of energy usage chart and group activities.
C. Completion of weatherization or conservation measure and post-test.

3. Suggested Schedule/Time

Two weeks (less if only one activity is used).

Key Instructional Suggestions:

1. Safety

A. Stress ladder and climbing safety when working around the home.
B. Be aware of any hazards listed on insulation materials.
C. Remind students of safe work practices during installation activities.

2. Motivation

A. Run a contest for proposal with largest home energy cost reduction utilizing $500 of materials.
B. Schedule a day to take part in a community weatherization project.

C. Arrange press coverage of community service.

3. Prerequisite Information

A. Sufficient skills with tools to install weatherization.
B. Basic math skills.

4. Demonstrations

A. Demonstrate how to sketch and record measurements of a house.
B. Show steps in calculations and explain future projections.
C. Demonstrate weatherization techniques.
D. Give examples of entries on audits.

5. Reinforcement

A. Measuring, calculating area and utilizing other math concepts allows everyday use of math.
B. Emphasize that everyone will be paying residential, transportation and communication energy costs someday, and that wise practices will save them money.

6. Attitudes

One of the primary goals of this TAM is to encourage students to develop positive attitudes toward energy conservation. Students are frequently unaware of wasteful practices and of the limited supply of many of the resources that they use. Throughout the TAM, stress that energy conservation is essential as technological advances consume more and more. Emphasize ways they can respond to the critical problem of using up our resources.

7. Remediation/Enrichment

A. Pair poor math students with a stronger math student.
B. Faster students could volunteer to do a home energy audit for someone else or make a model of an energy efficient home (or wall section).

8. Summary & Review

A. Home energy audit.
B. Effective weatherization measures.
C. Personal energy use.
D. Importance of energy conservation.

9. Review Questions & Answers (Answers in italics)

A. List types of sources of energy in the world and give two examples of each.

A. Limited -- coal, oil, natural gas, uranium
B. Unlimited -- solar, wind, gravitational, tidal, geothermal, fusion
C. Renewable--wood, biomass gasification, biomass fermentation, animal power, human muscle power

B. What is the definition of energy?

Ability or capacity for doing work

C. What does R-value mean?

A number used to describe the resistance of a material to the flow of heat

D. List three weatherization practices that decrease the use of energy for heating.

Double or triple glazed windows
Storm windows
Caulking
Weatherstripping
Wall insulation

Date: ________ Class: ________ Name: ______________________________

TAM #13: Energy Audits - Pre-test

Instructions: Ask students to take this test when beginning the TAM. Instruct them to find unknown answers by reading pages 383-403 in Living with technology.

1. What is the definition of energy?
   - A. The distance an object moves multiplied by the force required.
   - B. Ability or capacity for doing work
   - C. Power that comes either from man or the sun
   - D. The amount of work done in a given period of time

2. What kind of an energy source is coal?
   - A. Limited
   - B. Unlimited
   - C. Renewable

3. What kind of an energy source is wind?
   - A. Limited
   - B. Unlimited
   - C. Renewable

4. What is an energy audit?
   - A. Study of sources of energy
   - B. Report of use of energy
   - C. Cost analysis of different kinds of energy
   - D. List of definitions

5. The principle of conservation of energy states that
   - A. We must not use limited energy sources
   - B. Potential energy is everywhere and always available
   - C. Energy cannot be created or destroyed, but it can be changed from one form to another
   - D. Heating is the biggest waste of energy in the United States

6. Why should we be concerned about our consumption of energy?
   - A. We could run out of some energy sources, such as oil
   - B. New technologies are consuming more and more energy
   - C. The increase in world population requires more energy
   - D. All of the above

Date: ________ Class: ________ Name: ____________________________

TAM #13: Energy Audits - Post-test

Instructions: Identify items 1 through 5 as a limited, unlimited or renewable source of energy.

1. Wood
2. Solar
3. Oil
4. Nuclear
5. Human and animal muscle power

Instructions: Choose the best answer for the following questions:

6. What is the definition of energy?
   - A. The distance an object moves multiplied by the force required.
   - B. Ability or capacity for doing work
   - C. Power that comes either from man or the sun
   - D. The amount of work done in a given period of time
7. A window that has an R-value of 2 loses heat much faster than a wall with an R-value of 20.
   - A. True statement
   - B. False statement
   - C. There would be no difference
8. Why are double-glazed windows or storm windows recommended in order to save on cooling and heating costs?
   - A. The air space between the glass slows the flow of heat
   - B. The extra layer of glass slows the flow of heat

TAM #13: Energy Audits - Test Keys

TAM #13- Pre-test Answers

1. B 2. A 3. B 4. B 5. C
6. D

TAM #13 - Post-test Answers

1. Renewable
2. Unlimited
3. Limited
4. Limited
5. Renewable
6. B
7. A
8. A

TAM #13: Energy Audits

Student Component

Introduction:

What if we ran out of gasoline? What about natural gas or home heating oil? It could happen. Scientists tell us that we can't keep using up our fossil fuels like we are right now. We're going to run out. Then what? That's what this TAM is all about. Technology is changing at an almost unbelievable pace. Much of the new technology is concerned with harnessing energy from different sources to do useful work for people. Some of the technology needs to be directed at finding other energy sources. Estimates predict that we have only a few hundred years' supply of oil and natural gas and about one thousand years' supply of coal at our current rate of consumption. Learn what you can do about this situation.

Competencies:

Following the completion of this TAM, you will be able to:

1. Define and explain technical terms related to the study of home and personal use of energy.
2. Identify and describe limited, unlimited and renewable sources of energy in the world, in the U.S.A., and in Missouri.
3. Employ a systematic process to audit the use of energy.
4. Describe various home weatherization measures, citing the characteristics, advantages, and cost effectiveness of each.
5. Demonstrate the safe and proper use of energy weatherization tools, equipment, materials and processes.
6. Select and install an energy conservation measure.
7. Employ individual and group problem-solving processes to analyze data and graphically display results.
8. Recognize and respond to the need for energy conservation in residential, commercial, industrial and transportation applications.
9. Identify and evaluate the merits of various energy conservation measures for home/industry.

Module Overview:

You are a consumer of energy in nearly every aspect of your life. How you live now, and twenty years from now, is affected by the amount and cost of energy available for home use, transportation, communication and other industrial uses. During this activity, take a look at the amount of energy you and others use. Then learn about some energy conservation practices and select a way you can implement at least one conservation measure. Energy conservation will mean more money in your pocket now and/or later.

The study of energy and power is important because it directly affects your life. This TAM will help you understand the effects energy and power technology has on society in economic, environmental, psychological and sociological terms.

Key Information:

1. **Class Presentations**
   - Identifying sources of energy
   - Completing energy usage chart
   - Completing home energy audit
   - Decision making and projecting into the future
2. **Demonstrations**
   - Calculating procedure for audit and chart
   - Home weatherization installation
3. **Safety**
   - Home maintenance safety
   - Product safety
   - Manufacturer's liability
4. **Personal Activity**
   - Complete the pre-test given by the instructor to the best of your ability.
   - Read pages 383-403 in Living with Technology to find answers to the questions you did not know. Afterwards, complete the pre-test correctly.
5. **Other**

   Browse through the materials on energy in the classroom to get an overview of the widespread use of energy.

Glossary:

1. **Batt** -- A sheet of insulation of fixed length and width.
2. **BTU** -- Standard measurement of heat. A lit kitchen match will produce about one BTU of heat.
3. **Caulk** -- Compound used for filling and sealing cracks to prevent air leakage and condensation around windows, openings, or any place where two different materials meet.
4. **Insulation** -- A material having a relatively high resistance to heat flow and used primarily to reduce the flow of heat.
5. **Kilowatt-hour** (1,000 watt hours) -- A unit of electrical energy equal to the energy delivered by the flow of one kilowatt of electrical power for one hour. For example, a 100-watt bulb burning for 10 hours will consume one kilowatt-hour of energy.
6. **R-value** -- A statistical value used here to describe the resistance of a material to the flow of heat. The larger the R-value of the material, the higher the insulative value.

Needed Materials:

1. **Supplies**
   - A. Activity #1
     1. Pencil
     2. Calculator (optional)
     3. Paper

   - B. Activity #2
     1. Ruler or measuring tape
     2. Insulation materials where appropriate and possible

2. **Equipment - Activity #2**
   - A. Hammer
   - B. Scissors
   - C. Caulking gun
   - D. Ladder
   - E. Stapler

3. **Handouts**
   - A. Student component of TAM #13
   - B. Energy Usage Chart
   - C. Home Audit Form

4. **Instructional resources**
   - A. Numerous charts and pamphlets available from utility companies and Missouri State Department of Natural Resources
   - B. Technology textbooks, especially those on energy and power

TAM #13: Energy Audits

Activity #1: Personal Energy Usage Chart - Plan of Procedure

1. Complete the pre-test given by the instructor to the best of your ability.
2. Read pages 383-403 in Living with Technology to find answers to the questions you didn't know so you can complete the pre-test correctly.
3. Participate in class discussion on energy, its sources and uses.
4. Use the Energy Usage Chart (see Handout 1) to record the following:
   A. Record in detail all the activities you do in a 24 hour period (column 1).
   B. List the type of energy related to each activity. Example: electricity, gasoline, etc. (column 2).
   C. Establish the source of the energy used, e.g., wood, sun, fossil fuel (column 3).
   D. Classify as a limited, unlimited or renewable source (columns 4-6).
   E. Approximate the time and amount of energy consumed in each activity and supporting activities. Consult chart in The Missouri Energy Management Handbook for Homeowners for appliance consumption (columns 7-8, as appropriate).
   F. Unit cost (column 9).
   G. Total cost (column 10).
5. Collect data (each individual in the class) for one 24 hour period to complete chart.
6. Find cost of energy sources using classroom and home resources.
7. Calculate the energy costs for each activity and put in appropriate column.
8. Calculate the total cost for energy to support you in the 24 hour period.
9. Share your data with a group of classmates (3 or 4) by completing the summary chart (Handout 2). The chart is completed by estimating and computing the percentage of total energy consumed by each student for each category. For example, Student A could have used 30% of a $30.00 daily total energy use for entertainment, 20% for transportation, 15% for food, 30% for housing, and 5% for work. After individual percentages have been estimated, compute the average for each category for the group.
10. Transfer the information from the the summary chart to make a pie chart that will graphically display the percentage of energy in each category for your group. (See page 387 in Living with Technology).
11. Make another pie chart showing the average percentage of limited, unlimited and renewable energy sources used by your group.
12. Make a bar graph showing the individual minimums and maximums in the categories used for the pie charts.
13. Post your graphs on the bulletin board to compare percentages with other teams in the class.

14. Read pp. 359-375 in Understanding and using technology, which is about decision making and choices. Write a list of the four related parts of a decision and use this list to help your group in the next step.

15. As a group, write your three best strategies for the future use of energy, each on a separate 3" x 5" card.

16. For each of the strategies, write three results or consequences, either good or bad, on one half of a 3" x 5" card.

17. Glue the cards on a large sheet of paper or poster board as shown in the example below (see Fig. #1).

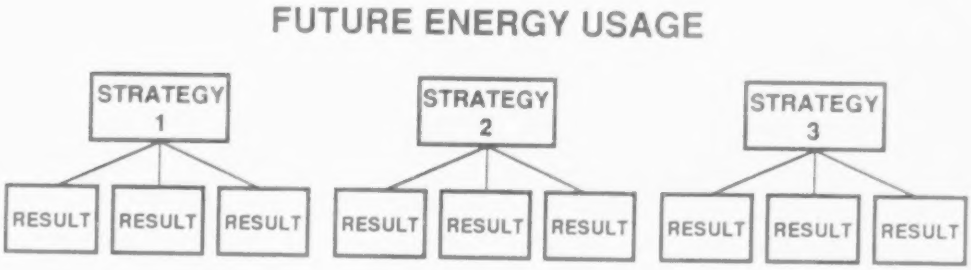

FUTURE ENERGY USAGE
STRATEGY 1
STRATEGY 2
STRATEGY 3
RESULT
RESULT
RESULT
RESULT
RESULT
RESULT
RESULT
RESULT
RESULT

Figure #1 - Sample Strategy Display

18. Letter an appropriate title for the display.

19. Share your poster with the class - each of you must have a part in the oral presentation to the class.

TAM #13: Energy Audits

Activity #2: Energy Audit - Plan of Procedure

1. Refer to the Home Energy Audit Worksheet (Handout 3).
2. Sketch four elevation views and a floor plan of a one-story home (demonstrate on a model house, if available).
3. Measure and record overall wall, window and door dimensions on sketch.
4. Identify District Heating Factor from chart.
5. Identify fuel used to heat this house and its local cost.
6. Discuss standards for evaluating weatherstripping and caulking of house.
7. Calculate total square footage of windows and doors in the entire house.
8. Describe types of window glazing -- single, double, and triple.
9. Calculate R-value of floors, ceilings, and walls as directed on audit.
10. Calculate heating costs with computer program or by hand.
11. Demonstrate installation of insulation materials and caulking.
12. Research cost of weatherization materials.
13. Decide whether to include labor costs.
14. Calculate potential savings by adding weatherization measures.
15. Make recommendation, based on cost-effectiveness, for spending $500 (more or less) on weatherization for the audited house and project savings.
16. Discuss impacts of home energy conservation.
17. Help add weatherization at home or take part in a community weatherization project as a group.

TAM #13 - Summary

1. **Review & Summary Activities**

   Review the opinions of several conservation groups concerning estimates of how long our fossil fuel supplies will last at current rates of consumption.

   On the basis of what you have learned in this TAM, which alternative energy resources do you think technology should be developing in order to supply energy needs far into the future?

2. **Review Questions -- Test yourself!**

   On the basis of current rates of consumption, when will fossil fuel reserves be depleted?

   Instructions: Name four of the most effective steps that can be taken to increase the efficiency of energy use in a typical residence.

   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________

   Instructions: List and discuss at least four alternative energy resources that hold great promise as future energy sources.

   1. ______________________________
   2. ______________________________
   3. ______________________________
   4. ______________________________

TAM #13 - Post-assessment

Instructions: Choose the best answer for the following questions.

1. What is the definition of energy?
   - A. The distance an object moves multiplied by the force required
   - B. Ability or capacity for doing work
   - C. Power that comes either from man or the sun
   - D. The amount of work done in a given period of time
2. A window that has an R-value of 2 loses heat much faster than a wall with an R-value of 20.
   - A. True statement
   - B. False statement
   - C. There would be no difference
3. Why are double-glazed windows or storm windows recommended to save on cooling and heating costs?
   - A. The air space between the glass slows the flow of heat
   - B. The extra layer of glass slows the flow of heat
4. Identify items "A" through "E" as a limited, unlimited or renewable source of energy.
   - A. Wood
   - B. Solar
   - C. Oil
   - D. Nuclear
   - E. Human and animal muscle power

Personal Energy Usage Chart

Name: ____________________

ACTIVITY	ENERGY USE	ENERGY SOURCE	Limited, Unlimited, Renewable			TIME	ENERGY USE	UNIT COST	TOTAL COST
			L	U	R				

Name: ______________________

SUMMARY CHART

CATEGORIES OF ENERGY USAGE STUDENT NAME:	ENTERTAINMENT	TRANSPORTATION	FOOD	HOUSING	WORK	HEALTH/PERSONAL	MISCELLANEOUS			$ UNIT TOTAL
AVERAGE:										
AVERAGE CHANGE:										

Energy Audit Form

DOE/CS-0105

Project RetroTech

Revised
July 1979

U.S. Department of Energy
Assistant Secretary for Conservation
and Solar Applications
Office of Weatherization Assistance

Washington, D.C. 20585

REFERENCE NO. ________

B

HOME WEATHERIZATION JOB BOOK FOR PRIORITY SETTING

____
Street Address (or Building Type if for sample evaluation)

____
Town (or Area if for sample calculation)

This revised Job Book replaces the original Retrotech Job Book and is used in much the same way. Additional information is developed which allows priority of various weatherization measures for a building to be determined as required by the National Energy Conservation Policy Act.

The booklet is also intended to be used for determining costs of weatherization measures and consequent fuel savings for sample buildings of frequently occurring types in an area, e.g. ranch houses, colonials, row houses, etc. to establish a priority listing which will hold for all similarly constructed buildings in the area. This procedure eliminates the necessity for using a Job Book for every building where many buildings of a particular type are of similar construction.

Home Evaluation

Inspection by ________________ Date ________

Calculation and Priority sections by ________________ Date ________

Description of Building

Sketch all views and put dimensions on each part shown, for example, length of walls, width and length of windows, etc. Label all single glass windows S and double glass and doors D. Complete all items in the job book labeled "Fill in at Job Site."

**FILL IN
AT JOB SITE**

Front View

Left Side View

Plan View

These grids are provided as guides for lines. Drawings need not be done to scale.

Right Side View

Rear View

Calculation of Floor Area

If the building is not rectangular or square add the areas of the various parts together to find the floor area.

Building Length ft.

Building Width ft.

Floor Area sq. ft.

District Heating factor (see page 8) ☐

FUEL USED TO HEAT THIS BUILDING				COST PER HEATING UNIT ($)
☐	Oil	______ ($ per gallon)	× 1 =	☐
	OR	______ ($ per therm)	× 1.2 =	☐
☐	Natural Gas	______ ($ per cu ft)	× 120 =	☐
☐	Propane	______ ($ per lb)	× 6 =	☐
☐	Electricity	______ ($ per kwh)	× 30 =	☐
☐	Coal	______ ($ per ton)	× .005 =	☐
☐	Wood	______ ($ per cord)	× .007 =	☐

Do not complete this list when evaluation is for a typical building

Dwelling Unit Information

Name of Head of Household ______

Name and Address of Owner: (if not the same as above) ______

Number of Occupants ______

Age and Style of Building ______

Type of Fuel Used

______ Primary ______ Secondary

Type of Heating System ______

Type of Domestic Hot Water Heater ______

Winter Thermostat Setting

______°F Day ______°F Night

Amount of Fuel Used Last Winter ______

Heat Losses by Conduction Through Ceilings

Area of Ceiling
(Take area of upstairs ceiling in a two-story house)

Ceiling area will normally be the same as floor area (from building description sheet)

Always include the materials in the roof deck in addition to the materials in the actual ceiling, as even if the attic is ventilated the roof deck adds some protection. Include the attic as an air space with R = .91.

Material	Thickness (inches)	R Value
inside surface	—	0.68
Outside Surface	–	0.17
	Total R value	

FILL IN
AT JOB SITE

If the Job Book is for a sample house complete both sections 1 and 2 below. For a specific house complete the section which describes the actual ceiling.

(1) Heat losses through uninsulated ceilings

If the Job Book is being completed for a sample house it is necessary to determine the potential heat savings for those examples **without** insulation. If the sample house has some insulation, subtract its R value from the total above and calculate the heating units required without insulation as below.

☐	×	☐	÷	☐	=	☐
Ceiling area sq. ft.		District heating factor		Total R value		Heating units required

(2) Heat losses through partially insulated ceilings

If ceilings are partially insulated, e.g. to no more than R-10, further savings can be made by adding insulation. However, the primary savings have already been made and the investment in **extra** insulation may not be as worthwhile as some other measures. Evaluate the savings by the calculations below, using R = 10 for a sample building or actual R value for an individual house to determine what priority should be assigned to this measure.

☐	×	☐	÷	☐	=	☐
Ceiling area sq. ft.		District heating factor		Total R value		Heating units required

(Use R = 10 for sample houses)

The appropriate amount of insulation for a ceiling depends on climate, fuel prices and insulation costs. Check the current DOE recommendation on maximum appropriate R value for your area. This indicates the maximum amount of insulation which will be cost effective for your climate. Any less amount of insulation than this will **save less total fuel** but will **save more per dollar spent.**

☐	×	☐	÷	☐	=	☐
Ceiling area sq. ft.		District heating factor		Appropriate R value		Potential heating units

Subtract the potential heating units from those now required for uninsulated or partially uninsulated ceilings and enter here:

		Potential savings
1.	Conduction through Uninsulated ceilings	

		Potential savings
2.	Conduction through Partially insulated ceilings	

Heat Losses by Conduction Through Floors

Do not complete this page for concrete slab floors. Heat loss due to them is usually small but cannot be evaluated by this method.

Floor Exposure Factor

Select the appropriate factor from the descriptions below:

Building on posts or pillars with no perimeter protection	1.0
Building on posts or rocks with some protection against wind blowing under building	8
Tight skirt or foundation wall around perimeter	5
Tight foundation wall with equivalent of R4 or better insulation on inside or outside of wall	3

R value of floor

A typical uninsulated, uncarpeted wood floor will have an R value of about 3. Carpet and pad will increase the R value to 5.

FILL IN
AT JOB SITE

Potential Savings on Heat Loss through Floors

☐	×	☐	×	☐	÷	☐	=	☐
Floor area (from building description) sq ft		Floor exposure factor		District heating factor		Floor R value from above		Heating Units Required

1. Reducing below floor drafts

Unless vigorous underfloor ventilation is needed to remove moisture rising from the ground, a floor should be protected from drafts, so that it has a floor exposure factor of only 0.5. If the floor in this building has an exposure factor over 0.5., cutting out drafts below the floor could reduce the heat loss to:

☐		0.5	×	☐	÷	☐	=	☐
Floor area from above sq. ft.		Floor exposure factor		District heating factor		Floor R value from above		Potential heating units

2. Adding Insulation

EITHER (a) The perimeter wall of the crawl space or basement can be insulated (with R = 4 or better) down to grade level or just below, to cut both drafts and conduction losses, reducing the floor exposure factor to 0.3. The heat loss with an insulated perimeter would be approximately:

☐	×	0.3	×	☐	÷	☐	=	☐
Floor area from above sq. ft.		Floor exposure factor		District heating factor		Floor R value from above		Potential heating units

OR (b) Where perimeter walls cannot be insulated because the insulation would become wet (if water seeps through the basement walls or if water rises above the level of the insulation or if underfloor ventilation is needed) the whole floor may be insulated instead of the perimeter. This is usually more expensive than perimeter insulation but can give extra savings. Insulating this floor with a minimum of 3½" fiberglass between the joists will increase the R value to 15. More insulation will increase the R value further still. The potential heating units will be:

☐	×	☐	×	☐	÷	☐	=	☐
Floor area from above sq. ft.		Floor exposure factor (Use 0.5 if drafts can be eliminated. 0.8 if underfloor ventilation is needed)		District heating factor		Floor R value (minimum of 15		Potential heating units with whole floor insulation

Subtract the potential heating units for any of the three possible floor treatments which are feasible from the heating units now required and enter in the boxes below.

1	2a	2b
☐	☐	☐
Potential heating savings by reducing drafts	Potential heating savings by perimeter insulation	Potential heating savings by whole floor insulation

Heat Losses by Conduction Through Uninsulated Walls

(Partially insulated frame walls cannot normally be further insulated.)

R Value of Outside Walls

Uninsulated frame walls usually have a total **R value around 3.0** no matter what type of interior finish or siding treatment is present. If the wall is of different construction list all materials in the wall in the table at right, starting from inside and including air spaces within the wall. Insert R value for each component from Table 1.

**FILL IN
AT JOB SITE**

Material	Thickness (inches)	R Value
Interior surface	–	0.68
Outside surface	–	0.17
	Total R value	

	×		=	
Total perimeter of outside wall ft.		Total height of outside wall ft.		Gross wall area sq. ft.

	–		=	
Gross wall area sq. ft.		Total area of all windows and doors from sketches on pages 2 and 3		Net wall area sq. ft.

	×		÷		=	
Net wall area		District heating factor		Total R Value		Heating units required

Potential Savings by Insulation

Fully insulated frame walls should have an R value of 15. If this were so for this building, the wall heat loss would be:

	×		÷	15	=	
New wall area (from box above)		District heating factor		R value		Potential heating units

Subtract the potential heating units from those now required and enter here

Type of Heat Loss	Potential Heating Savings
Conduction Through Uninsulated Walls	

Heat Losses by Conduction and Infiltration Through Single-Glass Windows

Area of Single Glass Windows:
(Assuming R = 1 for single glass)

Width ×	Height ×	Number =	Area
		Total sq. ft.	

If this Job Book covers a sample house determine the potential heat savings for single glass.

☐	×	☐	=	☐
Total sq. ft.		District heating factor		**Heating units required**

Potential Saving by Adding Storm Windows

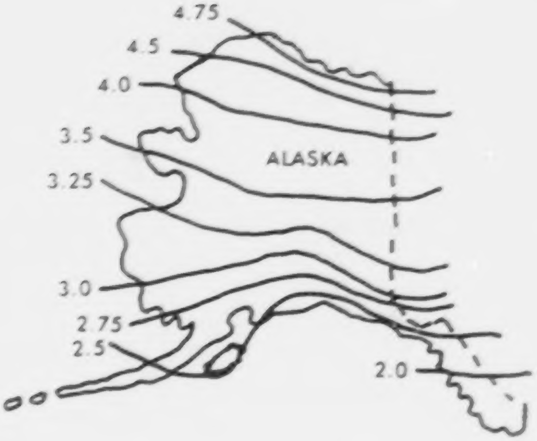
Adding storm windows will cut the conduction heat loss by half and will probably save half again by reducing infiltration. i.e. cut heat loss to 25%. Calculate the potential heating units below.

☐	×	.25	=	☐
Heating units now required with single glass				Potential Heating Units

Subtract the potential heating units from those now required and enter here

Type of Heat Loss	Potential Heating Savings
Conduction and Infiltration Through Single Glass Windows	

DISTRICT HEATING FACTORS FOR THE UNITED STATES


4.75
4.5
4.0
3.5
ALASKA
3.25
3.0
2.75
2.5
2.0

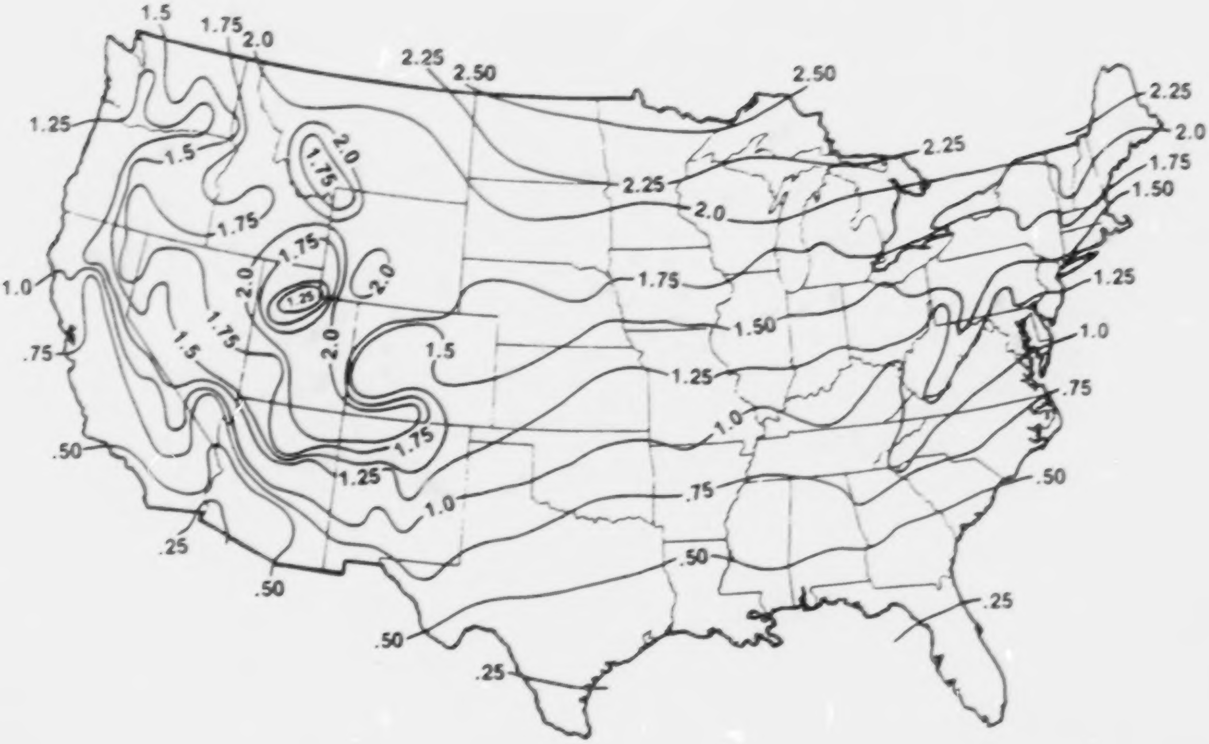

1.5
1.75
2.0
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Table 1: Insulation Value of Common Materials

This list is not intended to include all types of building materials, but only materials commonly used in residences. If necessary, select the material most similar, and the resulting values will not substantially affect the calculation.

MATERIAL	THICKNESS (Inches)	R VALUE
Air Film and Spaces:		
Air space, bounded by ordinary materials	¾ or more	91
Air space, bounded by aluminum foil	¾ or more	2.17
Exterior surface resistance	—	.17
Interior surface resistance	—	.68
Masonry:		
Sand and gravel concrete block	8	1.11
	12	1.28
Lightweight concrete block	8	2.00
	12	2.13
Face brick	4	.44
Concrete cast in place	8	.64
Building Materials — General:		
Wood sheathing or subfloor	¾	1.00
Fiber board insulating sheathing	¾	2.10
Plywood	⅝	.79
	½	.63
	⅜	.47
Bevel-lapped siding	½ × 8	.81
	¾ × 10	1.05
Vertical tongue and groove board	¾	1.00
Drop siding	¾	.94
Asbestos board	¼	.13
⅜" gypsum lath and ⅜" plaster	¾	.42
Gypsum board (sheet rock)	⅜	.32
Interior plywood panel	¼	.31
Building paper	—	.06
Vapor barrier	—	.00
Wood shingles	—	.87
Asphalt shingles	—	.44
Linoleum	—	.08
Carpet with fiber pad	—	2.08
Hardwood floor	—	.71
Insulation Materials (mineral wool, glass wool, wood wool):		
Blanket or batts	1	3.70
	3½	11.00
	6	19.00
Loose fill	1	3.33
Rigid insulation board (sheathing)	¾	2.10
Windows and Doors:		
Single window	—	approx. 1.00
Double window	—	approx. 2.00
Exterior door	—	approx. 2.00

Summary Table for Priority Rating of Weatherization Measures

Fill out the Summary Table at the right by entering the fuel cost per Heating unit from p. 3 in Column 4, and the Potential Heating Savings from pp. 4-8 in Column 5. Enter the estimated material cost for the required changes in Column 1, the appropriate Installation factor in Column 2 and the expected life of each Weatherization measure in Column 4. From these figures determine the Total Cost and Lifetime Savings from each measure, and then in Column 8 calculate the Benefit : Cost Ratio. Finally, in column 9, rank the weatherization measures in order of cost effectiveness.

Source of Heat Loss	Weatherization Measure Required to Minimize Heat Loss	Unit Cost of Material ($/ft^2)	Quantity of Material (sq. ft.)	1 Total Material Cost Unit Cost × Quantity) ($)
General Waste of Heat	See separate Job Order Sheet	—	—	—
Uninsulated Ceilings (from p. 4)	Insulate to Local Standard of R =			
Partially Insulated Ceilings (from p. 4)	Insulate to Local Standard of R =			
Exposed Floors (from block 1 page 5)	Reduce Exposure factor to 0.5			
*Uninsulated Perimeter (from block 2a page 5)	Insulate perimeter with R=4 or better			
*Uninsulated floors (from block 2b page 5)	Insulate floor with R=11 or better			
Uninsulated Walls (from p. 6)	Insulate Wall to R=15			
Single Glass Windows (from p. 7)	Add Glass Storm Windows			
	Other:			

*Only one of these alternate measures is usually applied to a specific building. See Weatherization Manual for details.

Recommended Weatherization Priority List

Enter the various sources of heat loss and appropriate weatherization measures from the Summary Table above in priority order in the list at right. This is the order of importance of weatherization measures in a building of the type examined regardless of size or age. A copy of this list should be included in the local Building Check and Job Order Sheet for this type of building.

2 Labor Cost to Install (If appropriate)	3 Total Cost (Col 1 + Col 2) ($)	4 Expected Life of Weatherization Measure (years) OR Expected Life of Bldg., whichever is least	5 Potential Heat Savings from bottom of pages 4-8 (Heating Units/year)	6 Fuel Cost per Heating Unit (from page 3) ($/HU)	7 Lifetime Savings due to Weatherization Measure (Col 4 × Col 5 × Col 6) ($)	8 Benefit: Cost Ratio (Col 7 ÷ Col 3)	9 Order of Cost Effectiveness
—	Usually Small	—	Usually Substantial	—	—	Usually Favorable	1

RECOMMENDED WEATHERIZATION PRIORITY LIST

for ______________________ in ______________________ by Job Book Reference No. __________
(building/type) area/address

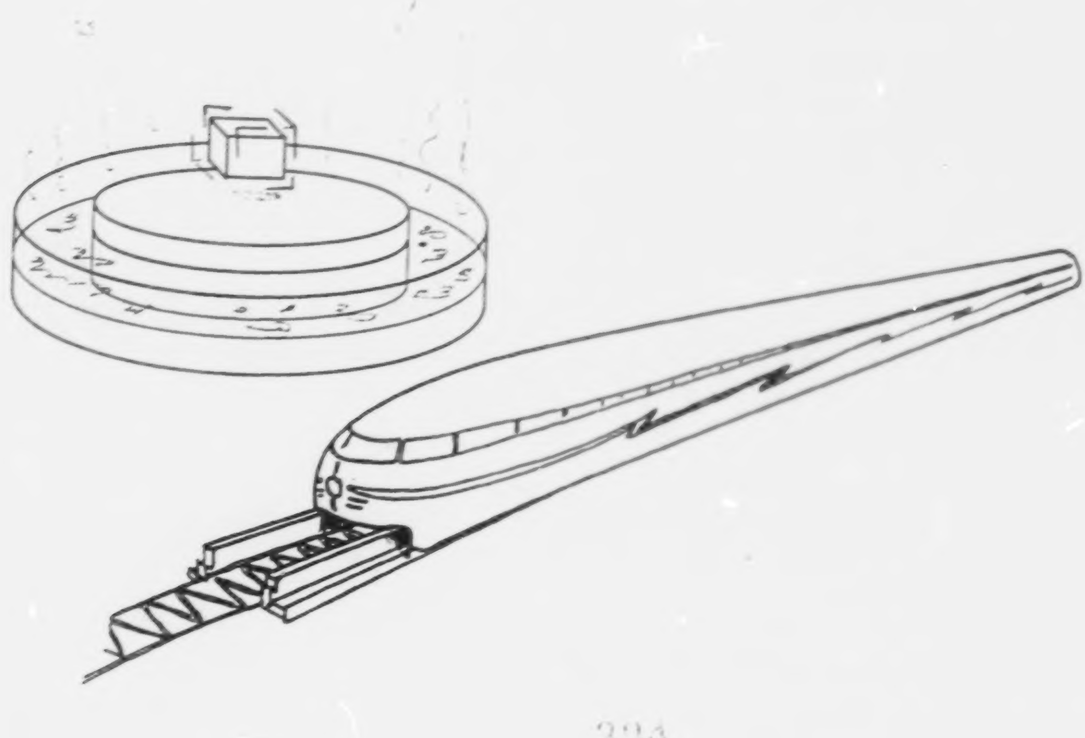
Priority	Source of Heat Loss	Weatherization Measure Required	Approximate Allowable Unit Cost of Materials	If list is for a Typical Building check if item is included on Job Order Sheet or note reason for omission
1	General Heat Waste	See Job Sheet	—	
2				
3				
4				
5				
6				
7				
8				
9				

Course:	Introduction to Energy & Power Technology

Technology Activity Module #14

Superconductivity: Speeding into the Future

by: Steve Murray



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TAM #14: Superconductivity: Speeding into the Future

Instructor Component

Activity Objectives: **The purpose of this activity module is to reinforce the concepts of superconductivity and its applications in a technological world. These concepts will be introduced through demonstrations and a laboratory activity.**

Activity Competencies: By completing this TAM, the student will be able to:

1. Demonstrate the safe use of equipment, tools, materials, and processes that are related to energy and power technology.
2. State the advantages and limitations of various modes of material and/or human transportation systems such as railroads, automobiles, robots, mass transit, pipelines, etc.
3. Describe the functions of transportation systems in the movement of people and goods.
4. Describe the components of transportation systems.
5. Project alternative futures for current transportation systems.
6. Describe the safety aspects of transporting goods and people.
7. Explain the pollution problems posed by the use of various transportation systems.
8. Experiment with processes, equipment, and materials to develop insight into new and advancing energy & power technologies.

Module Instructions

Introduction:

Superconductivity is a relatively new technology that has been making headlines in many newspapers and magazines. The concepts related to superconductivity and their potential for application are almost limitless. This module consists of two activities that can be easily introduced in electronics or transportation. These activities include a superconductivity demonstration and the construction of a magnetically levitated train.

Safety Considerations:

- Students are to observe standard safety procedures for operating equipment that are established by the instructor.
- Safety glasses are required at all times while in the laboratory.
- Gloves are required for those handling liquid nitrogen.

Needed Materials:

1. Supplies Required

Superconductivity Demonstration

- Tongs
- Liquid Nitrogen
- Dish
- Superconducting disc
- Rare earth magnet

Mag-Lev Train

- Two 40" strip magnets
- Copper Magnet Wire, 30 gauge
- 5/16" x 2-1/2" bolts, nuts, & washers
- Two 6-volt batteries
- Rotary switch (12 - 20 position)
- 1" x 2-1'/2" x 36" pine stock
- Two pieces of acrylic plastic (1/8 to 1/4 thick), 2" wide x 36" long
- Small permanent magnet
- Hot glue
- Styrofoam or other lightweight materials

The demo kit can be ordered from:

Creative Learning Systems
9899 Hibert, Suite C
San Diego, CA 92131
Item 6016-TF9 $34.99

or

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007-1380
Item 738,169 $36.00

2. Equipment/Machines/Tools

Superconductivity Demonstration

- Safety glasses
- Safety gloves

Mag-Lev Train

- Drill and 5/16" & 1/4" drill bit
- Hot glue gun
- Table saw and dado blade

3. Handouts

Student component of TAM #14

4. Instructional Resources

A. [illegible]deo/Slides

[illegible] Cryogenics
NOVA Video
Educational Network
Rent or purchase

2. Superconductivity Above Liquid Nitrogen Temperatures
VHS Video. Item 5021-TF9
from Creative Learning Systems.
Price $49.99.

B Books and Articles

1. _____. (1989, February). Superconductors and other electromagnetic materials. The Technology Teacher, p. 15-22.
2. Buxton, Rick. (1988, September). Making superconductors in the technology laboratory. The Technology Teacher, p. 33-37.
3. Fisher, Arthur. (1988, April). Superconductivity. Popular Science, p. 54-58.

4. Fisher, Arthur. (1989, December). Super (conductor) man. Popular Science, p. 76-77.
5. Free, John & Scott, David. (1989, May). 310-mph flying trains - in the 90's - in the U.S. Popular Science, 114, p. 132-135.
6. Mayo, Jonathan L. (1988). Superconductivity: The threshold of a new technology. Blue Ridge Summit, PA: TAB Books Inc.
7. Pope, Gregory T. (1988, June). Supertrain. Popular Mechanics, 114, p. 78-89.
8. Simon, Randy & Smith, Andrew. (n.d.). Superconductors: Conquering technology's new frontier. Order from Creative Learning Systems. Item 816-TF9. Price $23.99.

C. Computer Program

Electricity and Magnetism Series
Focus Media Inc.
839 Stewart Ave.
Garden City, NY 11530
1-800-6468989

Management/Logistics:

1. Related TAMS

This TAM ties in well with TAMS #6 - Physics Revealed and TAM #17 - Applying Electric Motors.

2. Evaluation/Grading

A. Evaluate the magnetically levitated train according to its correct operation and assembly.
B. Evaluate the pre- and post-tests taken by the student.

3. Suggested Schedule/Time

The time suggested for this TAM is one to two weeks.

Key Instructional Suggestions:

1. Safety

A. Students are to observe all general safety procedures for operating equipment which have been outlined and discussed by the instructor.
B. Safety glasses are required at all times while in the laboratory.
C. Gloves and a laboratory apron are required for those handling liquid nitrogen.
D. Do not allow any liquid nitrogen to touch your skin.
E. Do not touch anything that has been immersed in liquid nitrogen until that item warms up to room temperature.
F. Do not allow liquid nitrogen to splash from its container while moving it.
G. Never obtain more than 1 liter of liquid nitrogen at a time.
H. Use liquid nitrogen in a well-ventilated area. Liquid nitrogen gas, while non-toxic, can displace oxygen in the air in an enclosed space and cause asphyxiation.

I. Do not store liquid nitrogen on any surface except those designed for it. Most surfaces will be damaged by the extreme cold.
J. Do not pour liquid nitrogen on any surface except those designed for it. Most surfaces will be damaged by the extreme cold.
K. Dispose of liquid nitrogen by allowing it to evaporate slowly in a well-ventilated area, preferably in its container. You can pour it into the soft soil of a flower bed, for example, where it can evaporate and return to the atmosphere.
L. Do not handle the superconductors with your hands.
M. Wash your hands with soap and water after the experiment is completed.
N. Do not expose the superconductor disc to water or temperatures above 90 degrees Fahrenheit.
O. Use caution in the handling of electromagnets. They will become very hot when in use.

2. Motivation

Observing the Meissner Effect and using the superconductivity demonstration kit should stimulate student interest. You may also wish to show a video on superconductivity and demonstrate a magnetically levitated train.

3. Prerequisite Information

No prerequisite information is needed to participate in the TAM. However, student learning will be enhanced by reading from the suggested reading list prior to participation.

4. Demonstrations

A. Meissner effect
B. Magnetic field using a permanent magnet and an electromagnet
C. Magnetically levitated train

5. Reinforcement

The study of superconductivity provides an excellent opportunity to reinforce basic science principles, particularly those from chemistry and physics. Learning in this area could be enhanced by working cooperatively with science teachers within your school or from a local college or university.

6. Attitudes

A. Remember general safety rules when operating equipment.
B. Housekeeping and cleanliness are very important.
C. Be very attentive and calm during the demonstration of the Meissner effect.

7. Remediation/Enrichment

Remediation: This can be done by showing a video about superconductivity trains and by assigning some additional background reading.

Enrichment: You may wish to have students discuss potential applications of a true superconductor (zero resistance at room temperature) as it relates to electric motors and computers. They can also be encouraged to relate superconductors to space transportation due to colder temperatures. One additional possibility for enrichment would be to have them discuss the advantages (environmental, safety, etc.) of mag-lev train transportation.

8. Summary & Review

In this TAM, we have ventured into the future of superconductivity and magnetically levitated trains. We have personally witnessed the Meissner effect and possible applications of superconductors. The following items should be reviewed:

A. Attraction/repulsion of magnetic poles.
B. Relationship of superconductors to transportation, electronics, etc.
C. Definition of a true superconductor.
D. Types of magnetically levitated trains.

9. Review Questions & Answers

A. A __________ is a material that will conduct electricity without any resistance at room temperature. *(superconductor)*

B. A __________ __________ __________ makes use of superconductivity electromagnets for transportation. *(magnetically levitated train)*

C. The __________ __________ demonstrates the principle of repulsion between magnets and superconductors. *(Meissner effect)*

D. An __________ produces a magnetic field when current flows through coils of wire. *(electromagnet)*

Date: ________ Class: ________ Name: ____________________________

TAM #14: Superconductivity - Pre-test

Instructions: Indicate whether the following statements are **True** or **False** by placing either a **T** or an **F** in the blank provided.

____ 1. Liquid nitrogen isn't dangerous and little precaution is necessary when handling it.

____ 2. Superconductors can carry a current without any loss of energy.

____ 3. Cryogenics is the study of how low temperatures affect current flow.

____ 4. A magnetically-levitated train is a slow means of transportation.

Instructions: For each blank space, provide the correct word or phrase to complete the sentence.

5. The ______________________________________ demonstrates the principle of repulsion between magnets and superconductors.

6. A ________________________ is a material that will conduct electricity without any resistance at room temperature.

7. One should wear ____________________ while handling liquid nitrogen.

8. A ________________________ is a material that will permit current to pass through it.

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #14: Superconductivity - Post-test

Instructions: Select from the list of words below and match with the correct definition. Place the word in the blank beside the definition.

Conductor
Kelvin
Voltage
Cryogenics
Absolute Zero
Current
Resistance
Drag
Meissner Effect

______________ 1. The temperature at which a substance has no molecular motion and generates no heat.

______________ 2. A substance that allows electricity to flow through it.

______________ 3. The study of the behavior of materials at low temperatures (Kelvin 233 to 0).

______________ 4. A measurement of the flow of electrons in a conductor.

______________ 5. Air resistance against a moving object.

______________ 6. A scale of temperature, measured from absolute zero.

______________ 7. The property of superconductors that makes them expel magnetic lines of force.

______________ 8. The opposition to the flow of electrons in a conductor.

______________ 9. The electromotive force that pushes electrons through a conductor.

Completion: Place the word in the blank that completes the statement.

10. ____________________ operate on principles of magnetism.

11. Another name for supertrain is ____________________.

12. List four modes of transportation.
    - ________________________________
    - ________________________________
    - ________________________________
    - ________________________________

TAM #14: Superconductivity - Test Keys

TAM #14 - Pre-test Answers

1. F   2. T   3. T   4. F
5. Meissner effect
6. superconductor
7. gloves and safety glasses
8. conductor

TAM #14 - Post-test Answers

1. Absolute Zero
2. Conductor
3. Cryogenics
4. Current
5. Drag
6. Kelvin
7. Meissner Effect
8. Resistance
9. Voltage
10. Supertrains
11. Bullet Train
12. Air, Land, Water, Space

TAM #14: Superconductivity: Speeding Into the Future

Student Component

Introduction:

Superconductivity can be defined as a phenomenon where materials conduct a current without any resistance. Recent developments have produced superconductors that conduct current without resistance at 54° Fahrenheit below zero. This temperature can be achieved easily by pouring liquid nitrogen on a superconductor. Unfortunately, this isn't practical; however, considering that four years ago the superconductivity temperature was about 800° Fahrenheit below zero, this is a remarkable achievement.

Competencies: Following the completion of this TAM, you will be able to:

1. Demonstrate the safe use of equipment, tools, materials, and processes that are related to energy and power technology.
2. State the advantages and limitations of various modes of material and/or human transportation systems such as railroads, automobiles, robots, mass transit, pipelines, etc.
3. Describe the functions of transportation systems in the movement of people and goods.
4. Describe the components of transportation systems.
5. Project alternative futures for current transportation systems.
6. Describe the safety aspects of transporting goods and people.
7. Explain pollution problems posed by various transportation systems.
8. Experiment with processes, equipment, and materials to develop insight into new and advancing energy & power technologies.

Module Overview:

What do 54° Fahrenheit below zero and trains have in common? 300 plus miles per hour! That means that it would take you one hour to travel from Los Angeles to Las Vegas or one hour from St. Louis to Kansas City. Now that's fast! These possibilities are coming about because of recent developments in superconductivity. If a true superconductor is ever developed, the possibilities are unlimited. For example, the number and size of computer circuits could be reduced because, without resistance, there would be no heat from current flow.

Superconductivity will revolutionize industry as we know it today. It will affect almost all technologies including transportation, electronics, communications, and material processing. As we discussed energy and power applications in transportation, we found that there are four modes of transportation: land, water, air, and space. Superconductivity has a direct relationship with land and space transportation technology - specifically, trains and planetary exploration.

The concept of supertrains (magnetically levitated trains) has been around for a while, but it was very expensive and not practical. However, recent developments in superconductivity have rekindled interest in supertrains. The supertrains operate on the principles of magnetism. Supertrains use either magnetic attraction or repulsion for their levitation, propulsion, and control. The shape of the trains usually resembles a bullet to achieve minimal wind resistance. As a matter of fact, these trains have been nicknamed "Bullet Trains".

Superconductivity will also allow for the further miniaturization of electronic circuitry used in communication, energy & power, and material processing, specifically computers. This miniaturization comes about because zero resistance results in zero heat energy given off. Since heat is the major enemy of electronics, it usually requires a cooling system. Eventually, heat will destroy an electronic component. Theoretically, through using superconductors, a current will travel through it indefinitely until it is used and not create any heat. The miniaturization of electronics will allow more compact devices. The possibilities are almost unlimited.

Key Information:

1. Class Presentations

- Concept of superconductivity
- Impact of superconductivity on society and industry
- Applications of superconductivity in transportation and electronics
- Concepts of magnetism and electromagnets
- Practical application in supertrains

2. Demonstrations

- Meissner effect
- Magnetically levitated train

3. Safety

- Students are to observe all general safety procedures for operating equipment which have been outlined and discussed by the instructor.
- Safety glasses are required at all times while in the laboratory.
- Gloves and a laboratory apron are required for those handling liquid nitrogen.
- Do not allow any liquid nitrogen to touch your skin.
- Do not touch anything that has been immersed in liquid nitrogen until that item warms up to room temperature.
- Do not allow liquid nitrogen to splash from its container while moving it.
- Never obtain more than 1 liter of liquid nitrogen at a time.
- Use liquid nitrogen in a well-ventilated area. Liquid nitrogen gas, while non-toxic, can displace oxygen in the air in an enclosed space and cause asphyxiation.
- Do not store liquid nitrogen on any surface except those designed for it. Most surfaces will be damaged by the extreme cold.

- Do not pour liquid nitrogen on any surface except those designed for it. Most surfaces will be damaged by the extreme cold.
- Dispose of liquid nitrogen by allowing it to evaporate slowly in a well-ventilated area, preferably in its container. You can pour it into the soft soil of a flower bed, for example, where it can evaporate and return to the atmosphere.
- Do not handle the superconductors with your hands.
- Wash your hands with soap and water after the experiment is completed.
- Do not expose the superconductor disc to water or temperatures above 90 degrees Fahrenheit.
- Use caution in the handling of electromagnets. They will become very hot when in use.

4. Personal Activity

As a homework assignment, you should read about the concepts of superconductivity and magnetically levitated trains. These concepts are available in the school's library. Before starting this activity, you should read the following:

A. Fisher, Arthur. (1988, April). Superconductivity. Popular Science, p. 54-58.
B. Free, John & Scott, David. (1989, May). 310-mph flying trains - in the 90's - in the U.S. Popular Science, 159, p. 132-135.
C. Pope, Gregory T. (1988, June). Supertrain. Popular Mechanics, 114, p. 78-89.

Glossary:

1. **Absolute Zero** -- The temperature at which a substance has no molecular motion and generates no heat.
2. **Conductor** -- A substance that allows electricity to flow through it.
3. **Critical Temperature** -- The temperature at which superconductivity occurs in a material.
4. **Cryogenic** -- The study of the behavior of materials at low temperatures (Kelvin 233 to 0).
5. **Current** -- A measurement of the flow of electrons in a conductor.
6. **Drag** -- Air resistance against a moving object.
7. **Electromagnet** -- An iron core encircled by coils of wire that becomes magnetic when current flows through the wire.
8. **Kelvin** -- A scale of temperature measured from absolute zero.
9. **MagLev** -- Abbreviation for magnetic levitation.
10. **Meissner Effect** -- The property of superconductors that makes them expel magnetic lines of force.
11. **Resistance** -- The opposition to the flow of electrons in a conductor.
12. **Superconductor** -- A material that will conduct a current without any resistance.
13. **Voltage** -- The electromotive force that pushes electrons through a conductor.

Needed Materials:

1. Supplies Required

Superconductivity Demonstration

- Tongs
- Liquid Nitrogen
- Dish
- Superconducting disc
- Rare earth magnet

Mag-Lev Train

- Two 40" strip magnets
- Copper Magnet Wire, 30 gauge
- 5/16" x 2-1/2" bolts, nuts, & washers
- Two 6-volt batteries
- Rotary switch
- 1" x 2-1'/2" x 36" pine stock
- Two pieces of acrylic plastic (1/8 to 1/4 thick), 2" wide x 36" long
- Small permanent magnet
- Hot glue
- Styrofoam or other lightweight materials

The demo kit can be ordered from:

Creative Learning Systems
9899 Hibert, Suite C
San Diego, CA 92131
Item 6016-TF9 $34.99

or

Edmund Scientific Co.
101 E. Gloucester Pike
Barrington, NJ 08007-1380
Item 738,169 $36.00

2. Equipment/Machines/Tools

Superconductivity Demonstration

- Safety glasses
- Safety gloves

Mag-Lev Train

- Drill and 5/16" & 1/4" drill bit
- Hot glue gun
- Table saw and dado blade

3. Handouts

Student Component of TAM #14

TAM #14: Superconductivity: Speeding into the Future

Activity #1: Superconductivity Demonstration - Plan of Procedure

1. Instructor Start-up & Specific Instructions

   A superconductor reveals unique properties that result in magnetic repulsion. These properties are demonstrated by the Meissner effect. The Meissner effect occurs when a superconductor is cooled below its critical temperature while in a magnetic field which surrounds but does not change the superconductor. This results in the magnet floating above the superconductor.

   Caution: Working with liquid nitrogen can be extremely dangerous. Be certain that you have carefully reviewed and completely understand the safety considerations in the **Key Information** section of this TAM. **Also**, it is strongly recommended that this activity be done either as a demonstration by the instructor or with the instructor working directly with one other student in handling the material. **Again**, be certain to wear safety glasses and gloves (for handling liquid nitrogen).

2. Place the superconductor in the center of the dish.
3. Pour liquid nitrogen in the dish.
4. Using tongs, place the rare earth magnet in the center and above the superconductor.
5. The magnet should float above the superconductor.

TAM #14: Superconductivity: Speeding into the Future

Activity #2: Magnetically Levitated Train - Plan of Procedure

1. Instructor Start-up & Specific Instructions

   There are two types of magnetically levitated trains. One type achieves levitation by attraction and the other achieves levitation by repulsion. The power source for moving the train is also accomplished by either attraction or repulsion. Regardless of the method used, it results in a very efficient, virtually pollution free, and economic form of transportation. The magnetically levitated train that you will be building suspends and propels the train by magnetic repulsion.

2. Cut a 1/8" wide by 1/2" deep groove that is 1/2" away from each edge of the 36" pine stock. (Figure #1).
3. Cut a 1" wide by 1/2" deep groove that is centered on the opposite side of 1/8" groove.
4. Drill 5/16" holes, 1" center to center through the pine stock.

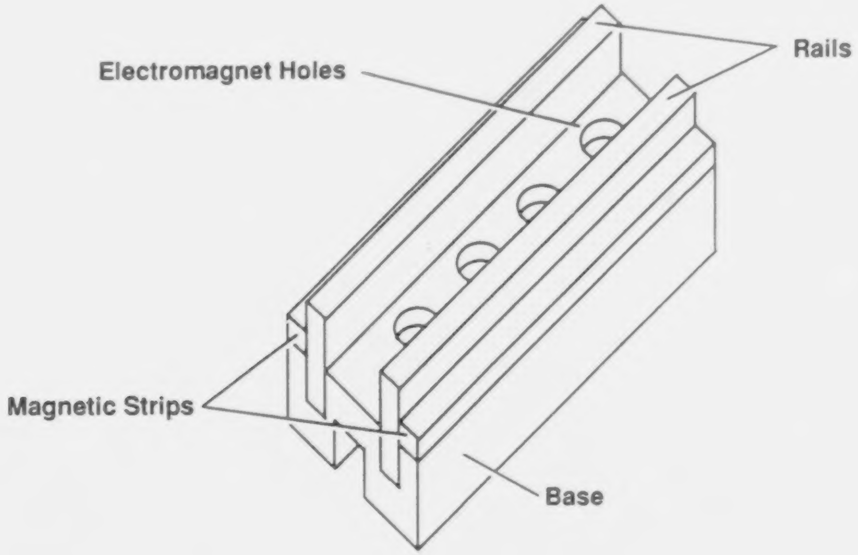


Figure #1 - Track Machining Detail

5. Assemble the nuts, bolts, and washers (Figure #2 - see next page). The washers are attached to the bolt head and nut.
6. Place threaded end of bolt into the electric drill and while the drill is turning, wind the magnet wire around the bolt until it is flush with the washers. Leave approximately 18" free on the start and end of wire. Follow this same procedure for all bolts.

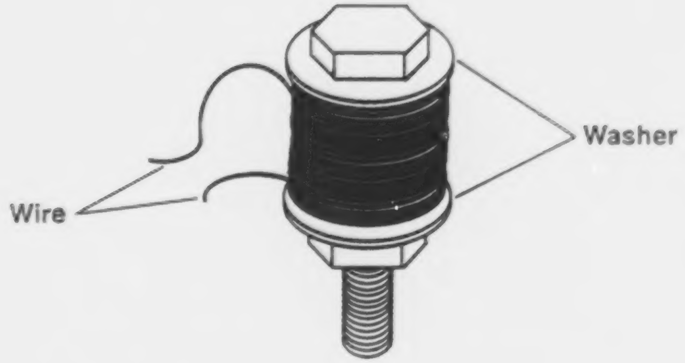


Figure #2 - Electromagnet Assembly

7. Attach the two 1 1/2" x 36" plastic strips in the 1/8" grooves with the hot glue gun.
8. Cut two magnetic strips to 36" long. Attach at the locations (Figure #3).

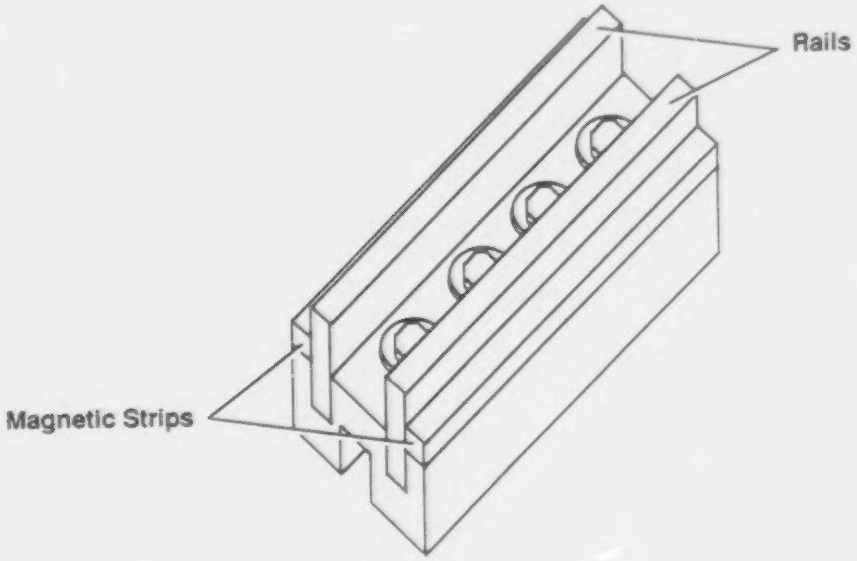


Figure #3 - Track Assembly

9. Design and build a train from lightweight material. The train should be about 4" and have a groove to fit plastic guides.
10. Cut two magnetic strips to the length of train and attach to the bottom of the train.

11. Place the electromagnets in the 5/16" holes. Place both through the hole as well (Figure #4).

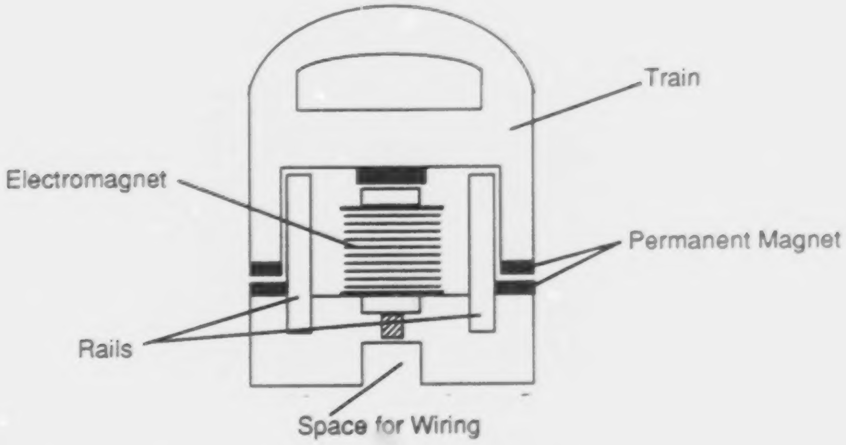


Figure #4 - Assembly Cross-section

12. Connect all starting wires to the battery's (+) post. Then run a wire to a center post of a switch to the battery's (-) post
13. Connect ending wires to a switch post. Make sure that the electromagnets are kept in order on the switch.
14. Connect to the two - 6 volt batteries.
15. Place the train on the track and test (Figure #5).

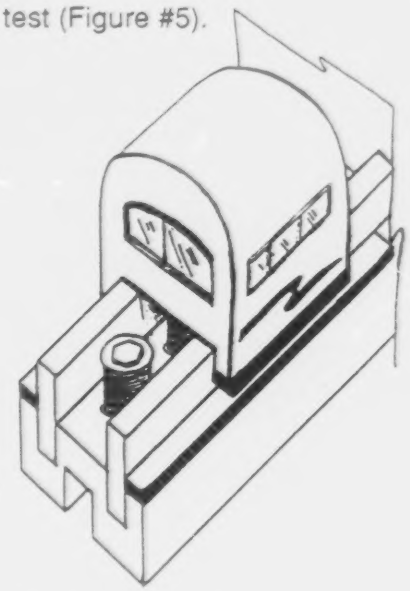


Figure #5 - Assembled Unit

TAM #14 - Summary

1. **Review & Summary Activities**

   In this TAM, we have ventured into the future of superconductivity and magnetically levitated trains. We have personally witnessed the Meissner effect and possible applications of superconductors. Perhaps you will discover the superconducting material that will revolutionize industry. By the way, when riding the supertrain make sure you wear your seat belts!!

2. **Review Questions - Test yourself!**

   A. A ______________________________ makes use of superconducting electromagnets for transportation.

   B. An ____________________ produces a magnetic field when current flows through coils of wire.

   C. How will superconductivity affect electronics?

   D. Another name for supertrains is ________________________.

   E. List the four modes of transportation.

   ______________________ ______________________

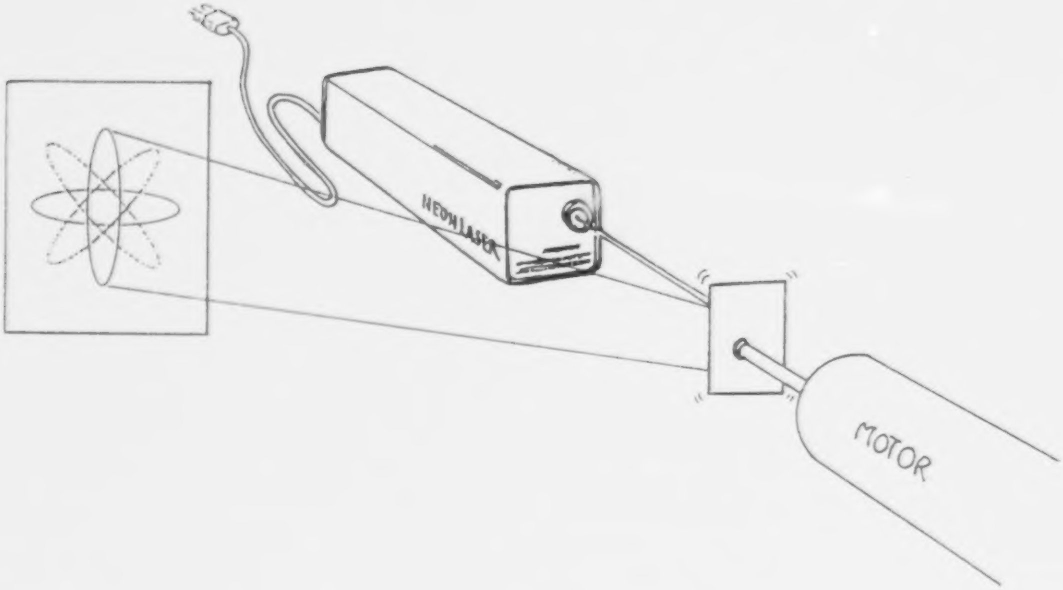
   ______________________ ______________________

Course:	Introduction to Energy & Power Technology

Technology Activity Module #15

Making Lasers Work for Us

by: Craig Adams



TAM #15: Making Lasers Work for Us

Instructor Component

Activity Objectives: The purpose of this TAM is to show students some of the fundamental concepts and skills needed when working with the laser as a power and energy source. The laser light show has been chosen due to its many uses of laser fundamentals and its popularity.

Activity Competencies: By completing this TAM, the student will be able to:

1. Use safe procedures when using the laser.
2. Understand the role that lasers have in the area of power and energy technology.
3. Use terms associated with the laser and its use.
4. Give advantages and disadvantages of using the laser as a power and energy source.
5. Gain experience in the use of laser beam control devices.
6. Solve problems relating to the use of the laser in each activity.
7. Understand the impact that lasers have made in power and energy technology.
8. Brainstorm future uses of the laser in power and energy technology.

Module Instructions

Introduction:

Most, if not all, students have either seen or heard of laser light shows, and have been fascinated by them. This technology, like many others, has been kept in the shadows, creating a mystical black box effect. Kids just don't know how or why they work, just that they are "cool".

Using this TAM, students will construct a few devices that are, in a more polished form, used in light shows like the "Lasarium" and those of many musical concerts. The student will not only construct the light shows, but in the process will learn how the laser works. Hopefully, they will also think about future applications in power and energy technology.

Safety Considerations:

The safety considerations when using a laser are many, indeed. However, that is not to say that the laser is too dangerous for the novice to use. It is just wise to know the risks involved before jumping in. Lasers can be both educational and fun, but in careless hands they are potentially very dangerous instruments. Extensive information on laser safety is contained in Handout 1 - Laser Safety.

Most of the projects in this TAM will require some construction or electrical work. It is necessary that all shop safety precautions include the use of woodworking, metalworking, electronics, and plastics equipment, as well as basic hand tool safety.

Needed Materials:

1. Supplies Required

All of the parts are either readily available or can be obtained at your local Radio Shack store.

A. Sound Modulating Mirrors

1. Planters peanut or chip can
2. 1 - 3 - 4-inch diameter speaker
3. 1 - latex rubber glove or surgical rubber, approximately 6 inches
4. 1 - thin mirror
5. 1 - rubber band
6. 1 - laser

B. Laser Spirograph

1. 3 or 4 small 1.5 to 6 volt DC hobby motors
2. 3 or 4 pennies
3. 1 - 4-inch square thin mirror
4. 3 or 4 light clamps (see diagram)
5. 1 - small camera tripod
6. 1 - laser

C. Motor Control Circuit (available from DDK Technologies)

1. 2 - 4011 CMOS NAND gate IC
2. 1 - 1 megohm resistor
3. 1 - 100 megohm potentiometer
4. 1 - 0.1 microfarad disc capacitor
5. 1 - 0.01 microfarad disc capacitor
6. 1 - IRF511 MOSFET power transistor (or equivalent)
7. 1 - DPDT switch, center off
8. 1 - heatsink for transistor
9. 1 - project box (available at Radio Shack)

All resistors are 5 to 10 percent tolerant, and 1/4 watt. All capacitors are 10 to 20 percent tolerant, and rated 35 volts or more.

D. Galvanometers (available from DDK Technologies)

1. 2 - small 1.5v or 6v DC hobby motor
2. 2 - light clamps
3. 2 - pennies
4. 1 - small piece of sponge, anti-static foam
5. 1 - 4 inch square piece of 1/4" hardboard or plywood

E. Galvanometer Driver Circuit (available from DDK Technologies)

1. 1 - LM741 op amp IC
2. 4 - 1 kilohm resistor
3. 1 - 10 kilohm potentiometer
4. 1 - 10 kilohm resistor

5. 2 - 0.1 ohm, 2-watt resistor
6. 2 - 27 kilohm resistors
7. 1 - TIP 41 npn transistor
8. 1 - TIP 42 pnp transistor
9. 1 - 1/8 inch jack
10. 1 - heatsink for transistors
11. 1 - project box (available from Radio Shack)
12. 1 - DPDT switch

All resistors are 5 to 10 percent tolerance, 1/4 watt, unless otherwise indicated.

F. Complete Light Show Circuit Parts List

1. 2 - Sine/Cosine generators
2. LM741 op amp IC
3. 10 kilohm potentiometer
4. 1 kilohm resistor
5. 10 kilohm resister
6. 1/8-inch miniature phone jack
7. DPDT switch

All resistors are 5 to 10 percent tolerance, 1/4 watt.

2. Equipment/Machines/Tools

A. Safety goggles or glasses
B. Laser safety goggles
C. Soldering irons (high wattage)
D. Hand tools
E. Glass cutter
F. Band saw
G. Hot glue gun
H. Hand drill
I. Drill press

3. Handouts

A. Handout #1: Laser Safety
B. Handout #2: Spiral Light Devices

4. Instructional Resources

A. Catalogs

B. Books

1. Iannini, R.E. (1987). Fiberoptic infrared and laser space age projects. Blue Ridge Summit, PA: TAB Books.
2. McComb, G. (1987). Laser cookbook. Blue Ridge Summit, PA: TAB Books.

C. Magazines

1. Photonics Magazine
2. Laser Focus World Magazine
3. NASA Tech Briefs Magazine

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Management/Logistics:

1. Related TAMS

Review the TAM presented in the Missouri Communications Technology Guide, 1990, entitled Laser Applications.

2. Evaluation/Grading

A. Pre-and post-test students.
B. Place a 60% emphasis on lab work and 40% emphasis on written work.

3. Suggested Schedule/Time

It is recommended that 2 weeks be spent on this part of the energy and power class. However, more or less time may be spent, depending on the type of class.

Key Instructional Suggestions:

1. Safety

There are several other safety precautions that need to be observed, such as solder iron safety, machine tool safety, etc. These should be covered in the basic shop safety tests prior to the implementation of this TAM.

2. Motivation

"With the photon, the unit of light, taking over the role previously dominated by the electron, the unit of electricity, we are at the edge of an entirely new universe of industrial enterprise." --Gov. Mario Cuomo of New York

"Photonics has the potential to revolutionize the world we live in." --Air Force Gen. Bernard Randolph

The area of photonics (lasers, fiber optics, etc.), is still in its infancy stage. Many of today's most influential people believe that for our country to remain globally competitive in high technology, we must move forward and take photonics into its adulthood. Research does support that the industry of photonics is such a fast-growing enterprise that it will generate many new, not yet named, jobs. Students should therefore prepare for those jobs by getting a broad-based knowledge of the field of photonics.

This TAM just shows one particular area of photonics, the laser light show. With the enthusiasm of the instructor and the excitement of light shows, the laser can be your ticket to providing your students with the "broad-based knowledge" that industry will be calling for.

3. Prerequisite Information

A knowledge of the safe use of shop tools is imperative.

4. Demonstrations

A. Laser safety
B. Laser properties
C. Laser techniques
D. Working with the sound modulating mirrors

E. Working with the laser spirograph
F. Working with the galvanometers

5. Reinforcement

This TAM reinforces basic principles from physics. When built into a light show, it can also reinforce some basic concepts from art and music as well.

6. Attitudes

Due to the high cost of lasers and their peripheral devices, it is hoped that students can gain an appreciation of the tools and what they can do. It is also essential that they realize the importance of precision and care when using these devices.

7. Remediation/Enrichment

Advanced students can actually construct the various devices needed for the activities or set up the band or vocal concert. As for the remedial student, he or she may need to have the initial demonstrations repeated before doing the activities.

8. Summary & Review

As a wrap-up for this activity, we like to "show our stuff" to the class. We do this both to reinforce what we have done and also to build up some of the students' self-confidence and pride in their work.

9. Review Questions

A. What does CDRH stand for?

B. Why is the CDRH important when working professionally with a laser light show?

C. Define these terms:

  1. Coherence
  2. Frequency
  3. HeNe
  4. Laser
  5. Modulation
  6. Monochromatic

D. What is one disadvantage of using the laser as a power and energy source?

E. What is most important when positioning the laser?

Date: ________ Class: ________ Name: ____________________________

TAM #15: Making Lasers Work for Us

Activity #1 Pre-Test Questions

1. What does the term modulation mean?
2. Draw a picture of the output you expect to see when the mirror is hooked up.

Activity #2 Pre-Test Questions

1. What devices would you use to control the laser beam output?
2. What is polarity? Why is it important?
3. What is a potentiometer?

Activity #3 Pre-Test Questions

1. What should you do before you use the laser and equipment?
2. Why has the laser become such a popular tool in the area of power and energy technology?
3. Name 2 disadvantages of using the laser for a power source.
4. What is a galvanometer?
5. What is frequency? Sine? Cosine?

Date: ________ Class: ________ Name: ______________________________

TAM #15: Making Lasers Work for Us - Activity #1 Post -Test

1. What happens to the light show when the volume knob is turned up? Down? Why does this happen?

2. Set up as shown (Figure #1). Note: Refer to Figure #6 in the Student Component for tin can/speaker/rubber/mirror assembly.

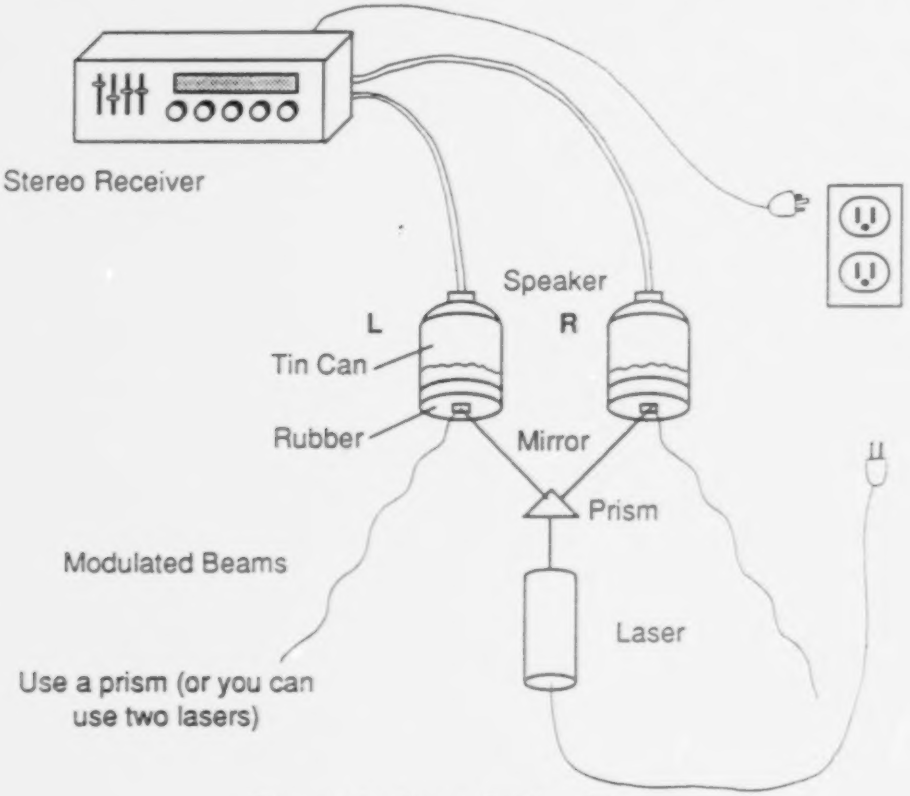

Stereo Receiver
Speaker
L
R
Tin Can
Rubber
Mirror
Prism
Modulated Beams
Laser
Use a prism (or you can use two lasers)

Figure #1 - Beam Splitter Setup

3. What will happen? Will the outputs be the same?

4. Try moving the treble and bass knobs. What happens?

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #15: Making Lasers Work for Us - Activity #2 Post -Test

1. Try to achieve these outputs (Figure #2).

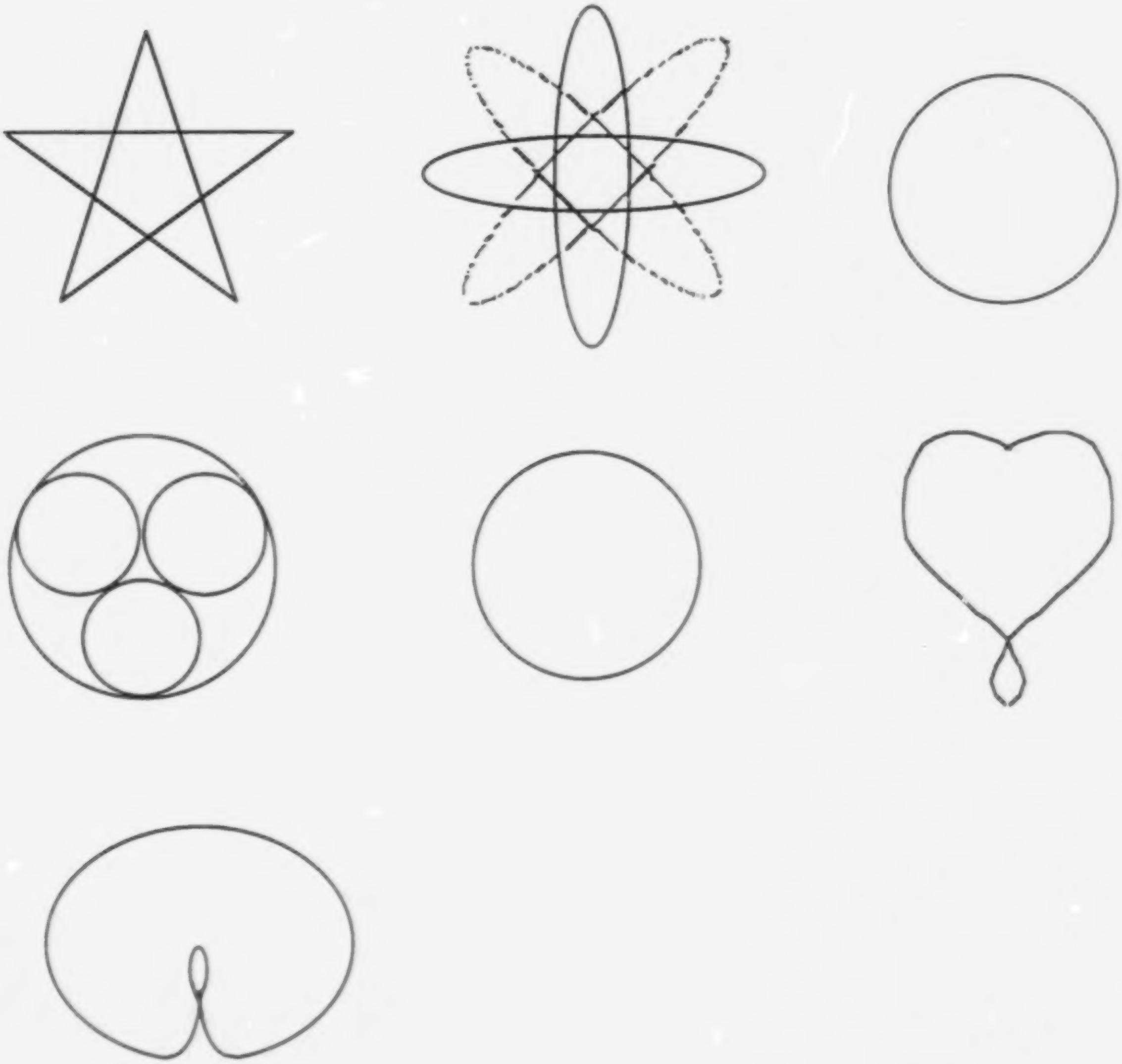


Figure #2 - Sample Outputs

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #15: Making Lasers Work for Us - Activity #3 Post -Test

1. Set up the laser as shown. (Figure #3). Note: Refer to Activity #3 in the student component for setup procedures.

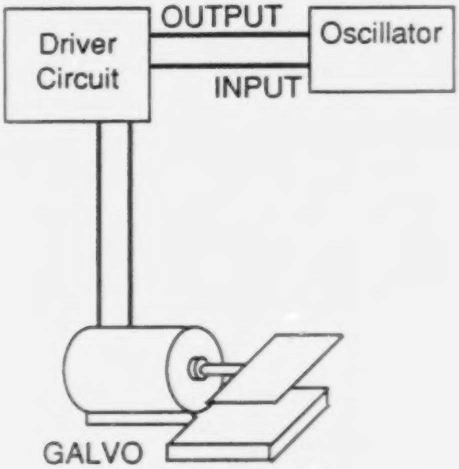

Driver Circuit
OUTPUT
INPUT
Oscillator
GALVO

Figure #3 - Laser Setup

2. Bounce the laser off the galvo to either a motor with a mirror (Activity #2) or to a sound-modulated mirror (Activity #1).

3. What does adding the galvo do to your laser light show?

4. What is the oscillator doing?

5. What is the driver circuit doing?

6. Set up as shown (Figure #4). Note: See Activity #2 in the student component for more information.

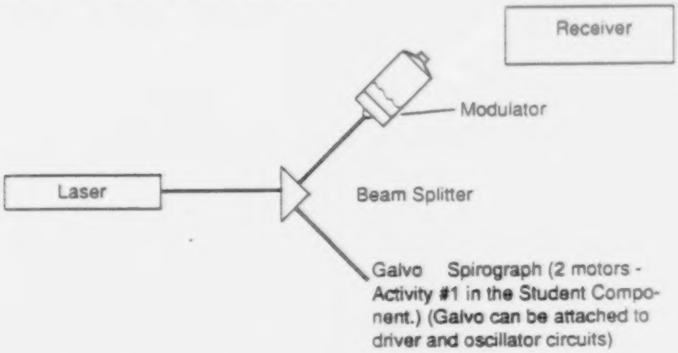

Receiver
Modulator
Laser
Beam Splitter
Galvo Spirograph (2 motors - Activity #1 in the Student Component.) (Galvo can be attached to driver and oscillator circuits)

Figure #4 - Alternate Laser Setup

7. Set up a large scale laser light show to go with a particular song or sound effect.
8. Explain how each of the light show devices works and what its function is:
    a. Laser
    b. Sound-modulated mirror
    c. Spirograph
    d. Galvanometer
    e. Driver circuit
    f. Oscillator circuit

Student Component

Introduction:

Most of us have either seen or heard someone tell us about how "cool" someone's light show was. Light shows are great to watch, but do you know how they are created?

In this activity you will construct your own light show using techniques that are used in the concert industry. You will also see how the light show technician gets the effects that he or she wants.

Competencies:

Following the completion of this TAM, you will be able to:

1. Use safe procedures when using the laser.
2. Understand the role that lasers have in the area of power and energy technology.
3. Use terms associated with the laser and its use.
4. Give advantages and disadvantages of using the laser as a power and energy source.
5. Gain experience in the use of laser beam control devices.
6. Solve problems relating to the use of the laser in each activity.
7. Understand the impact that lasers have made in power and energy technology.
8. Brainstorm future uses of the laser in power and energy technology.

Module Overview:

Lasers are becoming more and more useful in today's society. Their increasing use creates new jobs, and these need people who can handle them. This activity is intended not only to teach you about lasers, but also to show you the need for the broad-based learning experiences offered/supplied in Industrial Technology Education.

The laser illustrates energy application. It is one of the emerging technologies which will become even more important in the future.

Key Information:

1. **Class Presentations**
    - A. Laser safety
    - B. What is a laser?
    - C. Laser characteristics
    - D. Coherent light

    E. The helium neon laser
    F. Other laser
    G. Laser applications
    H. Laser occupations

2. Demonstrations

    A. Laser safety
    B. Proper handling of the laser
    C. Laser activities

3. Safety

Before participating in the activities, you should carefully read Handout 1-Laser Safety.

4. Personal Activity

It is suggested that in addition to the material given by the instructor to support this activity, you should research the subject as much as possible. A list of resource materials can be obtained from the instructor.

Glossary:

1. **Amplitude** -- The relative strength (usually voltage) of an analog signal. Amplitude can be expressed as either a negative or positive number referenced to a particular standard.
2. **Bandwidth** -- A continuous range of frequencies or wavelengths, defined by an upper and lower limit.
3. **Beam** -- A collection of rays (light waves) moving in one direction.
4. **Beam Splitter** -- An optical component that divides a beam two or more different ways. Beam splitters are rated by the ratio of light they reflect and transmit.
5. **Beamwidth** -- The linear width of the beam, usually specified as the region over which the beam intensity falls within pre-determined limits.
6. **Coherence** -- The property of identical phase and time relationship.
7. **Convergence** -- The bending of light by a lens or mirror to a common point.
8. **Diode Laser** -- A solid state injection laser, similar to a light emitting diode (LED).
9. **Divergence** -- The bending of light rays away from each other; the spreading of light.
10. **Fiberoptic** -- A solid glass or plastic "tube" that conducts light along its length.
11. **Frequency** -- The repetition rate of an electromagnetic wave, whether it be light or an electric signal.
12. **HeNe** -- Abbreviation for Helium Neon Laser.
13. **Laser** -- A mechanical device that produces intense, coherent radiation (mostly in the visible light and infrared regions). Laser is an acronym for light amplification by stimulated emission of radion.
14. **Modulation** -- Altering the characteristic of a wave by imposing another wave on top of it. Often used to carry intelligent communication signals over electromagnetic (radio and light) waves.
15. **Monochromatic** -- Possessing only one color; a specific wavelength (or a very restricted range) in the electromagnetic spectrum.
16. **Prism** -- An optical component, usually in the form of a wedge, that redirects a light beam by diffraction and reflection.
17. **Wave** -- In lasers, an oscillation, in the form of a sine wave, of electromagnetic radiation through a medium (or through a vacuum).

Needed Materials:

1. Supplies

All of the parts are either readily available or can be obtained at your local Radio Shack store.

A. Sound Modulating Mirrors

1. Planters peanut or chip can
2. 1 - 3 - 4 inch diameter speaker
3. 1 - latex rubber glove or surgical rubber, approximately 6 inches
4. 1 - thin mirror
5. 1 - rubber band
6. 1 - laser

B. Laser Spirograph

1. 3 or 4 small 1.5 to 6 volt DC hobby motors
2. 3 or 4 pennies
3. 1 - 4 inch square thin mirror
4. 3 or 4 light clamps (see diagram)
5. 1 - small camera tripod
6. 1 - laser

C. Motor Control Circuit (available from DDK Technologies)

1. 2 - 4011 CMOS NAND gate IC
2. 1 - 1 megohm resistor
3. 1 - 100 megohm potentiometer
4. 1 - 0.1 microfarad disc capacitor
5. 1 - 0.01 microfarad disc capacitor
6. 1 - IRF511 MOSFET power transistor (or equivalent)
7. 1 - DPDT switch, center off
8. 1 - heatsink for transistor
9. 1 - project box (available at Radio Shack)

All resistors are 5 to 10 percent tolerant, and 1/4 watt. All capacitors are 10 to 20 percent tolerant, and rated 35 volts or more.

D. Galvanometers (available from DDK Technologies)

1. 2 - small 1.5v or 6v DC hobby motor
2. 2 - light clamps
3. 2 - pennies
4. 1 - small piece of sponge, anti-static foam
5. 1 - 4 inch square piece of 1/4" hardboard or plywood

E. Galvanometer Driver Circuit (available from DDK Technologies)

1. 1 - LM741 op amp IC
2. 4 - 1 kilohm resistor
3. 1 - 10 kilohm potentiometer
4. 1 - 10 kilohm resistor
5. 2 - 0.1 ohm, 2-watt resistor
6. 2 - 27 kilohm resistors

        7. 1 - TIP 41 npn transistor
        8. 1 - TIP 42 pnp transistor
        9. 1 - 1/8 inch jack
        10. 1 - heatsink for transistors
        11. 1 - project box (available from Radio Shack)
        12. 1 - DPDT switch

        All resistors are 5 to 10 percent tolerance, 1/4 watt, unless otherwise indicated.

    F. Complete Light Show Circuit Parts List

        1. 2 - Sine/Cosine generators
        2. LM741 op amp IC
        3. 10 kilohm potentiometer
        4. 1 kilohm resistor
        5. 10 kilohm resister
        6. 1/8-inch miniature phone jack
        7. DPDT switch

        All resistors are 5 to 10 percent tolerance, 1/4 watt.

2. Equipment

    A. Safety goggles or glasses
    B. Laser safety goggles
    C. Soldering irons (high wattage)
    D. Hand tools
    E. Glass cutter
    F. Band saw
    G. Hot glue gun
    H. Hand drill
    I. Drill press

3. Handouts

    A. Laser Safety
    B. Spiral Light Devices

TAM #15: Making Lasers Work for Us

Activity #1: Sound Modulating Mirrors - Plan of Procedure

In this Activity you will construct a device to create a laser light show which will dance to the beat of the music. In other words, it modulates the beam. You will need to obtain the necessary equipment from your instructor and follow the safety rules listed.

1. Stretch a 6-inch piece of surgical rubber or a surgical rubber glove over a Planter's peanut or chip can and attach it with a rubber band.
2. Using a can opener, remove the opposite end and mount the speaker to fit. Use hot glue to hold it in place.
3. Mount a mirror in the center of the rubber with a little rubber cement.
4. Solder wires to the speaker and hook to a low-wattage stereo.
5. Attach the 1 1/4" PVC pipe as shown (Figure #5).

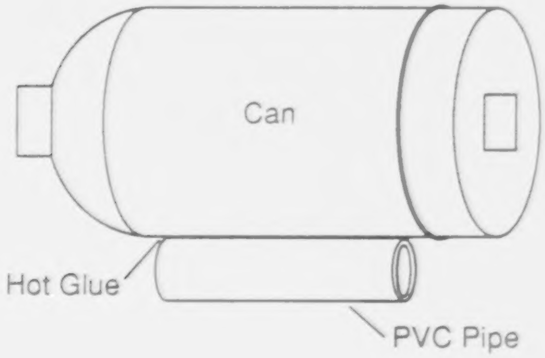


Figure #5 - PVC Pipe Assembly

6. Attach the clamp to the assembly as shown (Figure #6).

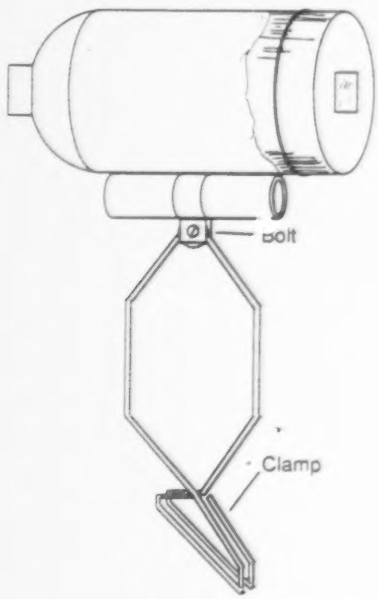


Figure #6 - PVC Pipe Assembly with Clamp

7. Mount the laser to the tripod and point it so the beam strikes the mirror.

8. Now turn on the stereo and turn up volume until you get a response.

TAM #15: Making Lasers Work for Us

Activity #2: Laser Spirograph - Plan of Procedure

With this activity you are on your way toward setting up your own controllable laser light show. You can experiment with different voltages and polarities to see what effect it has. If, instead of using switches and power supplies, you would like to use a motor control circuit, one can be built now. You will need to obtain all the necessary equipment and materials and get permission from your instructor to begin.

1. Drill a hole, slightly smaller than the motor shaft, in the center of a small copper disk (about the size of a penny).
2. Using some Super Glue, Liquid Steel, or JB Weld, glue the penny to the shaft of the hobby motor.
3. Glue the mirror, with hot glue, to the disk (mirror should be cut into 1" square pieces). Use rear surface mirrors due to their availability and durability.
4. Once the mirror has been attached to the motor and allowed to dry, attach it to the light clamps.
5. At this point you can either use the motors as they are or build the motor control circuit (parts list and schematic supplied). A knowledge of electronics is required to construct the circuit (a circuit is needed for each motor).
6. Position the laser so that the beam strikes the mirror in the center of the first motor.
7. Now position the other two motors so the laser will bounce in the center of all three (See Figure #7 - next page).
8. Turn on the first motor. You should see an ellipse or a circle.
9. You can, if you are not using the motor control circuit, hook up a DPDT switch to reverse the motor. If you use the circuit, it is provided.
10. Turn on all the motors. If you are using a variable power supply, turn up the voltage. What happens to your image?
11. Try turning off a motor to achieve different effects.
12. Add another motor. What happens?
13. If you are using the motor control circuit, try turning the potentiometers. What happens?

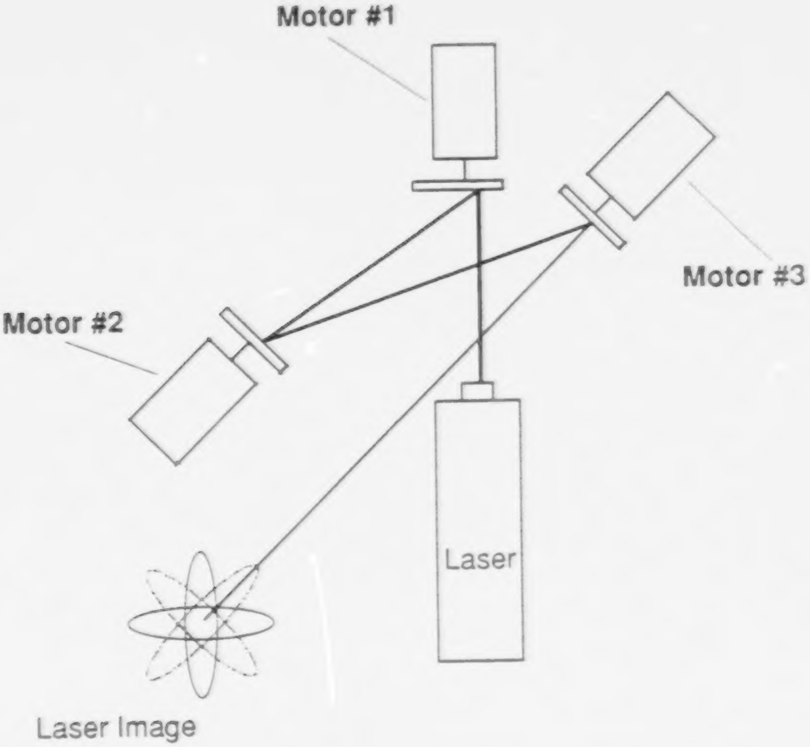

Motor #1
Motor #2
Motor #3
Laser
Laser Image

Figure #7 - Motor Positions

TAM #15: Making Lasers Work for Us

Activity #3: Galvanometer Construction - Plan of Procedure

With the last activity, you can construct your own galvanometers, just like the ones the professionals use to do their light shows (only a little more crude). Using galvanometers, your light shows will take on a whole new, more professional look. What you should do now is get the necessary equipment and materials and ask your instructor for permission to begin work.

1. Using a high-wattage solder iron, solder a solid copper disk (about the size of a penny) to the hobby motor shaft.
2. After the piece has cooled, glue a 1/2" by 1" mirror to the copper disk.
3. Using an adhesive, glue a piece of sponge to the other side of the copper disk.
4. Out of the 4" square piece of hardboard, trace and cut the following pattern (Figure #8).

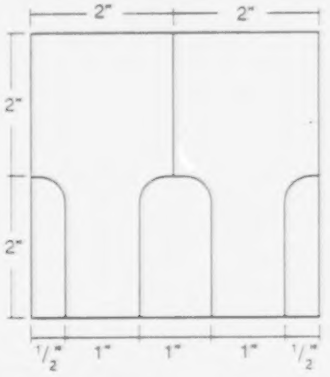


Figure #8 - Hardboard Base Mount

5. Hot glue the board to the motor as shown (Figure #9).

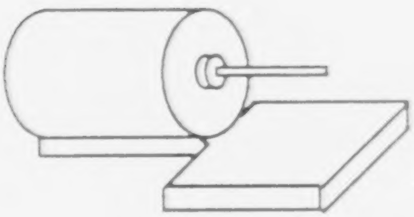


Figure #9 - Motor Attachment

6. After the hot glue has dried, another piece of sponge should be glued between the motor and board. Solder wires to the motor.

7. Now mount the galvanometer in a light clamp (Figure # 10).

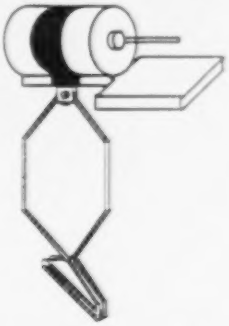


Figure #10 - Clamp Mounted Galvanometer

8. You can either use the galvanometer as it is, or you can build the galvo driver circuit and hook the galvo to it (Figure #11).

9. If using the driver circuit, you may turn the potentiometer and hit the DPDT switch to achieve different effects. If you are not using the driver circuit, you can wire a DPDT switch as shown (Figure #12).

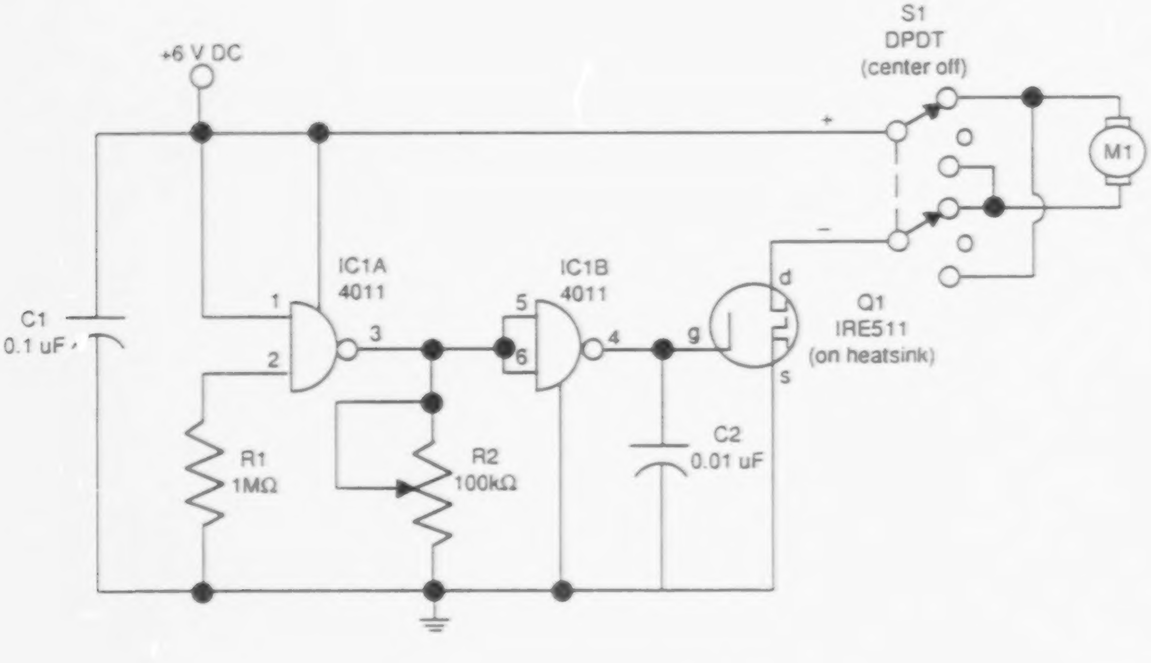

S1
DPDT
(center off)
+6 V DC
+
M1
−
IC1A
4011
IC1B
4011
d
Q1
IRE511
(on heatsink)
1
5
C1
0.1 uF
3
4
g
6
2
s
C2
0.01 uF
R1
1MΩ
R2
100kΩ

Figure #11 - Galvanometer Driver Circuit

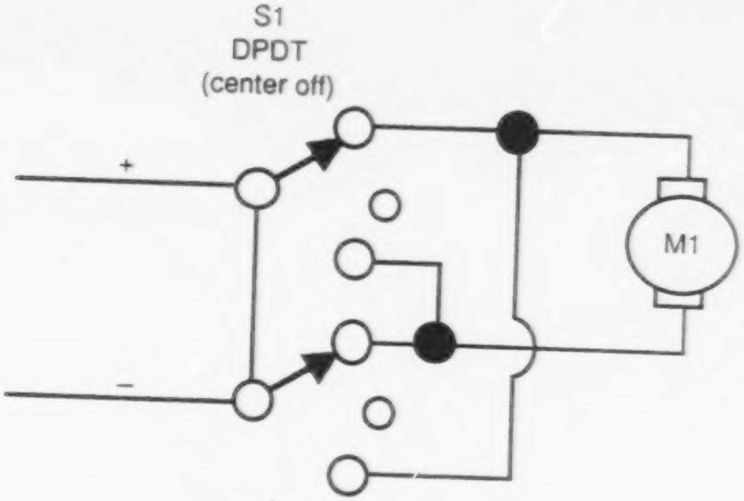


Figure #12 - DPDT Switch

10. The Laser Cookbook contains suggestions for some modifications which can be used to enhance your laser light show, such as using the oscillator circuit (schematic provided).

TAM #15 - Summary

1. Review & Summary Activities

There is no question, lasers are here to stay. The potential for applications is almost endless. Currently, they are used to align cars, check out groceries, and provide entertainment. Who knows what the future will hold?

TAM #15 - Post-assessment

Instructions:

Complete the TAM #15 post-assessment questions.

TAM #15 - Handout 1

TAM #15 - Laser Safety

The Center for Devices and Radiological Health (CDRH) has a strict set of laws regarding the use of commercially-bought lasers. Lasers are sold according to their power output. The CDRH regulates lasers to see that they comply with standards set to ensure that the dangers of laser radiation are kept to a minimum.

Lasers are divided into six classifications. Most of the lasers sold on the surplus market do not comply with the CDRH regulations. Below is a list of some of the simple functions to which regulations pertain.

The Dangers of Laser Light Radiation

The eyes are very susceptible to damage by the effects of focused laser light, the retina being the most susceptible. The longer the exposure and the more focused the beam, the greater the chance of damage to the retina. Retinal damage with the typical hobby lasers with outputs less than 10 milliwatts is rare, but it is good practice to make a habit of guarding against both accidental and intentional exposure. The effects of small doses of laser light over a long period could cause eye problems in later years. For that reason, it is wise to purchase a set of laser goggles, especially if certain practices cause the beam to strike your eyes. Even with the goggles, some light can still penetrate, so it is necessary to use caution.

The Dangers of High Voltage Electrocution

When using certain laser diode systems or the LED transmitter suggested in this TAM, there is no threat of exposure to high voltage due to the use of small household batteries. However, when working with all gas lasers, such as the HeNe hobby laser, it is necessary to use extreme caution due to the high-voltage power supplies. These power supplies can increase the voltage from 12 volts DC or 120 volts AC to several thousand volts. Unfortunately, some experiments tend to disregard this since the amperage is so low. However, current from a laser power supply, though it may not kill you, could cause you to jerk in such a manner that you could either fall or drop the laser, or worse yet, cause injury to someone else. Below is a list of some high voltage precautions.

The Danger of AC Electrocution

Most of the lasers that will be used in the school setting will operate on common AC house current. You should observe the same precautions when working with the laser as you would when working with any appliance. AC VOLTAGE CAN AND DOES KILL!!!

TAM #15 - Handout 2

TAM #15 - Spiral Light Devices

The following information gives some pointers for how to be successful in the development and use of spiral light devices.

- Keep the mirrors clean and free of dust or the light forms will appear streaked and blurred.
- Never adjust the position of the motors when they are turning. The mirrors are positioned close together, and moving the motors could cause the glass to touch. The mirrors will then shatter and fragments of glass will fly in all directions. It is a good idea to use protective goggles when adjusting and using the spiral light show device.
- Cheap DC motors like those used in this project make a lot of noise. You might want to use higher quality motors if you plan on using the "Spirograph" maker in a light show. Get ones with bearings on the shaft. You can also place the device in a soundproof box. Provide a clear window for the beam to come out.
- The "Spirograph" device is designed for manual control. With the right interface circuit, you can easily connect it to a computer for automated operation.
- You can obtain even more light forms by adding a fourth motor. Try it and see what happens.
- Don't be shy about turning some of the motors off. Some of the most interesting effects are achieved with just two motors.

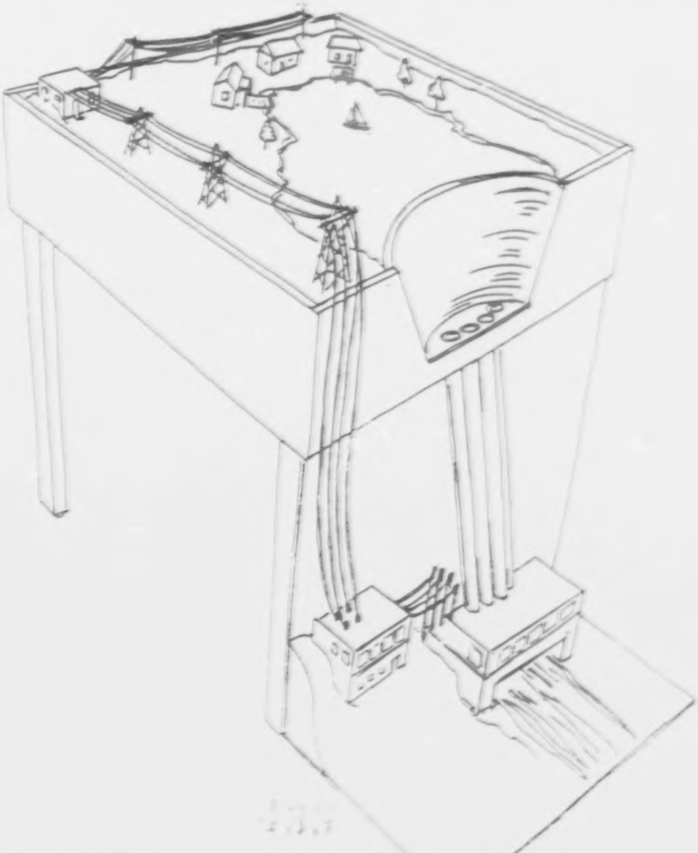
McComb, Gordon. (1987). Laser cookbook. Blue Ridge summit, PA: TAB Books. p. 238

Course:	Introduction to Energy & Power Technology

Technology Activity Module #16

Electrical Distribution Model

by: David Kempa



TAM #16: Electrical Distribution Model

Instructor Component

Activity Objectives: **The purpose of this activity is to expose students to principles and practices used in an electrical distribution system. These concepts are conveyed through field identification, modeling and laboratory experimentation.**

Activity Competencies: By completing this TAM, the student will be able to:

1. Develop problem solving and creative abilities involving the materials, equipment, processes, and products of electricity/electronics technology.
2. Define basic electrical terminology and units of measure.
3. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to electricity/electronic technology.
4. Exhibit positive work habits and attitudes as they relate to the safe and skillful operation of electric/electronic tools and equipment.
5. Use electronic components to build temporary and/or permanent circuits.
6. Describe the principles of magnetism and electromagnetism.
7. Relate the impact of electricity/electronics on our society.
8. Explain basic electrical laws and use them to solve assigned problems.
9. Operate basic electrical/electronic test instruments and equipment such as ammeters, voltmeters, ohmmeters, multimeters, oscilloscopes and the like.
10. Connect series, parallel and series-parallel circuits.
11. Describe the problems of high voltage distribution.
12. Explain systematic and safe procedures for setting up experimental circuits and servicing equipment.
13. Identify and define the sources of electricity.
14. Identify the major types of materials and supplies used in electricity/electronic technology.
15. Identify and describe the essential features of the equipment used in electricity/electronic technology.

Module Instructions

Introduction:

This activity is designed to combine guest speakers, walking field trips, modeling activities, problem solving, and laboratory activities. This TAM consists of three activities.

A. Field Experience: Distribution System

Here, students identify various electrical distribution equipment enlisting the aid of the Distribution Identification Sheet or a local electrical utility representative. Field sketching or photography may be incorporated into this activity. A guided trip to either a substation or local power plant may also be incorporated.

B. System Modeling: Distribution System

In this activity students work as a class and in small groups to construct a model distribution system. Small groups construct individual substations that are later tied together to form "the grid". Models from several different classes may be tied together to simulate interconnected service territories. Modeling techniques may be incorporated in various degrees as the instructor sees fit. Simulations of transformer failures, new customers and safety considerations may involve the application of Technological Procedures as outlined in Unit 2.

C. Power Loss Experiment

This activity requires the students to design and conduct an experiment in order to verify the distribution concept of line losses. Activities may be sequenced or broken out to stand alone. The depth to which an activity is pursued may be determined by either the instructor or the student's natural interest and curiosity.

Safety Considerations:

- Whenever possible, avoid work on energized circuits.
- Use extreme caution whenever voltage readings must be taken on live circuits.
- Obtain the instructor's permission when performing a measurement for the first time.
- Always exercise extreme caution whenever close to actual distribution systems. They are lethal.
- Avoid working with electrical circuits in the presence of water.
- Always make certain that all electrical circuits are properly grounded.

Needed Materials:

1. Supplies Required

A. Distribution System
  -Sketching supplies
  -Photographic film (optional)

B. System Modeling
  -Various modeling supplies
  -Hookup wire
  -(1) transformer 10:1 (300 VA)
  -(4-8) transformers 5:1
  -(8-20) six-volt light bulbs w/ sockets
  -4 x 8 sheet of plywood

C. Laboratory Experimentation
  -Wire of various sizes

2. Equipment/Machines/Tools

A. **Distribution System**

-Camera (optional)
-Variable AC power supply (0-30 VAC, 3A)

B. System Modeling

-Test equipment (VOM)
-Variable AC power supply (0-30 VAC, 3A)

C. Laboratory Experimentation

-Power supplies
-Light bulbs, etc.
-Multimeter (VOM)

3. Handouts

A. **Distribution System**

-Student component of TAM #16
-Sample Distribution Equipment
-Distribution Identification Worksheet
-Preassessment Quiz

B. System Modeling

-Student component of TAM #16
-Electrical Safety Handout
-Distribution System Component Sample Handout

C. Laboratory Experimentation

-Student component of TAM #16
-Line Loss Fact Sheet

4. Instructional Resources

A. Books

1. Bohn, Ralph. (1970). Power: Mechanics of energy control (pp. 143-147). Bloomington, IL: McKnight & McKnight.
2. Bubua, P. (1987). Understanding electricity and electronics technology (5th ed.), (pp. 468-475). New York: McGraw-Hill Cook Co.
3. Fowler, R. (1989). Electricity - Principles & application (3rd ed.), (pp. 154-162). New York: McGraw-Hill Book Co.
4. Groneman, C. (1988). General industrial education and technology (pp. 500-537). New York: McGraw-Hill Book Co.
5. Hacker, M. (1988). Living with technology (Ch. 13). Albany, NY: Delmar Publishing Co.
6. McClanahan, B. (1988). Scenery for model railroads. Milwaukee, WI: Kalmbach Books.
7. Mileaf, Harry. (1988). Electricity one-seven, (pp. 3-3 - 3-7). Hasbrouck Heights, NJ: Hayden Book Company.
8. Williams, C. (1985). Technology for tomorrow (pp. 122-126). Cincinnati, OH: South-Western Publishing Co.
9. Williams, C. (1987). Technology at work (pp. 158-160). Cincinnati, OH: South-Western Publishing Co.
10. Youngblood, P. (n.d.). Modeling cajon. Glendale, CA: Trans-Anglo Books.

B. Films/Videos/Guest lecturers/Support

1. Edison Electric Institute
   1111 19th Street, N.W.
   Washington, DC 20036-3691
2. Empire District Electric Company
   P.O. Box 127
   Joplin, MO 64802
3. Kansas City Power and Light Co.
   1330 Baltimore Ave.
   Kansas City, MO 64105

4. Missouri Public Service Company
10700 E. M350 Hiway
Kansas City, MO 64138

5. Union Electric Company
P.O. Box 149
St. Louis, MO 63166

Management/Logistics:

1. Related TAMS

There are no prerequisite TAMs. However this TAM incorporates concepts from the following:

- TAM #2: Adventures in Systems Analysis
- TAM #4: The Technology Assessment Process
- TAM #5: Energy Conversions
- TAM #7: Measuring Power

2. Evaluation/Grading

A. Pre- and post-tests taken by students.
B. Quality of the models in representing actual systems.
C. Rating of the laboratory experiment on accuracy, appropriateness and creativity.
D. Field sketches, based upon accuracy and appropriate detail.

3. Suggested Schedule/Time

Activity #1 may take from two to five days in order to spot and sketch a variety of distribution equipment. The instructor may choose to provide sketching guidelines to students or to conduct a comparative evaluation of the same component drawn by several different students.

Depending upon the degree to which authentic modeling practices are used, Activity #2 may last up to four weeks or more. The instructor is obligated to specify to students how much detail is expected. A simple bread boarded system may satisfy educational objectives, whereas a more authentic diorama may incorporate additional modeling skills and, consequently, more time.

The third activity is envisioned as a pre-packaged experiment with pre-calculated results which illustrates line losses and voltage regulation. Therefore, it should take only one or two hours. The instructor may opt for this approach based upon student capabilities, time and/or equipment limitations. However, should students be given the latitude to design their own experiment and analyze and report the results, the process may last considerably longer. Again, the instructor plays a big part in determining activity length.

Key Instructional Suggestions:

1. Safety

The primary safety threat with this TAM is electrical shock. Many experts agree that 200mA of current through the body can be lethal. An opportunity exists where Ohm's Law (the relationship of current to voltage and resistance) could be reinforced by developing examples of lethal voltages where the body's resistance drops to 300 ohms. Discuss the importance of staying away from actual distribution equipment where normal operating voltages may be as high as 345,000 volts. The instructor must establish safety rules and practices in which students are required to work. The use of insulated flooring material, ground fault circuit interrupters and safety glasses is recommended.

2. Motivation

Numerous possibilities exist for stimulating student interest with respect to distribution systems. If possible, obtain some tools associated with line work (insulated gloves, hot sticks, climbing spikes) to show the class. Arrange a visit to a sub-station or power plant or have a line truck visit the school. A representative from a power company could visit the class to discuss the various career options. You could have students calculate an electric bill or research an electric company's investment options (stocks) and corporate structure (stockholder's report).

3. Prerequisite Information

Due to the potential for danger it is critical that students be familiar with electrical safety procedures. They should also have some knowledge of basic electrical terms such as amp, volt, resistance, conductivity, and watt. It will also be necessary to provide students with an overview of an electrical distribution system (as outlined in cited references) as well as modeling techniques. You may also wish to introduce them to some basics of field sketching (optional).

4. Demonstrations

Demonstrations should be given on the safe use of electrical test equipment and power supplies.

5. Reinforcement

This TAM is rich with opportunities for reinforcing other academic subject areas. The study of distribution systems provides an excellent means for discussing basic math and science principles. You may wish to have a physician speak to the class about the physiology of electrical shock. Reinforcement also extends into student's thinking regarding careers and future leadership roles.

6. Attitudes

This TAM presents some excellent opportunities for reinforcing important attitudes. Whenever working with or using electricity in any form, many issues arise. Many persons are poorly informed as to how electricity is generated, distributed, and employed to their benefit in their everyday lives. Consequently, they may be fearful and exercise poor judgment as consumers of electricity and electrical products. Certainly one of the critical needs is for a citizenry which can appreciate the tremendous benefits of electrical power, its associated consumer issues (e.g., acid rain, nuclear waste, etc.) and appropriate general safety considerations.

7. Remediation/Enrichment

Remediation: Group remedial students with more advanced students. Show photographs of previous models, tours or events. You might wish to eliminate the last activity for those students needing remediation as it requires advanced skills in technological procedures.

Enrichment: Have students speculate on the impact of superconductors. The third activity could be expanded to accommodate the most inquiring minds. Develop/design advanced substation equipment or distribution schemes.

8. Summary & Review

In this TAM we have identified common electrical distribution equipment, constructed a model distribution system and verified power distribution concepts through the experimental process. With the knowledge acquired in this TAM, the student should be able to transfer these concepts to other power distribution systems (mechanical, fluid, etc.). The following are to be reviewed:

A. Energy conversion
B. Distribution equipment appearance and function
C. Reasons behind high voltage transmission
D. System reliability and availability
E. Line losses and voltage regulation

Date: ________ Class: ________ Name: ______________________________

TAM #16: Electrical Distribution Model - Pre-test

Instructions: Circle the letter that correctly answers the question.

1. Transformers are used in an electrical distribution system:
   A. In step up substations
   B. In step down substations
   C. At local points of distribution (back yards)
   D. All of the above
2. As electricity is passed through a conductor, energy is consumed through molecular friction. These losses are referred to as:
   A. Ambient losses
   B. Line losses
   C. Human error losses
   D. Catastrophic losses
3. A collection of interconnected devices where switching, voltage changing and metering take place is known as a:
   A. Bipolar switch
   B. Integrated chip
   C. NAND gate
   D. Substation
4. A watt is a unit of energy which is:
   A. The sum of voltage squared plus amperage
   B. The product of voltage and amperage
   C. Amperage minus voltage
   D. Voltage squared
5. A large energy conversion machine which coverts various sources of energy (stored water, coal, uranium) into electrical energy is called a:
   A. Electrical grid
   B. Rural electric cooperative
   C. Power plant
   D. Utility converter

Date: ________ Class: ________ Name: ____________________________

TAM #16: Electrical Distribution Model - Post-test

Instructions: Read each statement carefully and decide if the statement is **True** or **False** by placing a **T** or **F** in the blank.

1. ___ Electrical distribution conductors may be located overhead or underground.

2. ___ Most of the conductors used in an electrical distribution system are made of copper or aluminum.

3. ___ Power plants convert energy of one form (coal, natural gas, uranium) to electricity.

4. ___ Several substations are often tied together in order to increase an electrical distribution system's reliability.

5. ___ A general rule of thumb states that the more insulators found supporting a conductor, the greater the voltage.

6. ___ Wires used in overhead transmission and distribution service rarely have insulative coatings.

7. ___ You should not play around or climb actual distribution equipment.

TAM #16: Electrical Distribution Model - Test Keys

TAM #16 - Pre-test answers

1. D 2. B

TAM #16 - Post-test Answers

1. T 2. T 3. T 4. T
5. T 6. T 7. T

Student Component

Introduction:

Your CD player, camcorder, walkman, computer, and many other parts of your world depend on one thing to work...ELECTRICITY. How do you feel about electricity? Do you think about it? Is it just the invisible stuff that come from the plug or the battery and that's it? Did you ever give much thought to questions like: Where does it come from? What is it? How does it work?

The electricity used in your home and school is generated many miles away. Whenever electricity is passed through a wire, some energy is lost because of molecular friction in the wire. An electrical distribution system minimizes these losses and provides for reliable uninterrupted service. In this TAM we will visit and identify distribution equipment, design and construct a model distribution system, and conduct lab experiments to illustrate line losses.

Competencies: Following the completion of this TAM, you will be able to:

1. Develop problem solving and creative abilities involving the materials, equipment, processes, and products of electricity/electronics technology.
2. Define basic electrical terminology and units of measure.
3. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to electricity/electronic technology.
4. Exhibit positive work habits and attitudes as they relate to the safe and skillful operation of electric/electronic tools and equipment.
5. Use electronic components to build temporary and/or permanent circuits.
6. Describe the principles of magnetism and electromagnetism.
7. Relate the impact of electricity/electronics on our society.
8. Explain basic electrical laws and use them to solve assigned problems.
9. Operate basic electrical/electronic test instruments and equipment such as ammeters, voltmeters, ohmmeters, multimeters, oscilloscopes and the like.
10. Connect series, parallel and series-parallel circuits.
11. Describe the problems of high voltage distribution.
12. Explain systematic and safe procedures for setting up experimental circuits and servicing equipment.
13. Identify and define the sources of electricity.
14. Identify the major types of materials and supplies used in electricity/electronic technology.
15. Identify and describe the essential features of the equipment used in electricity/electronic technology.

Module Overview:

Why are transmission towers so tall? What is a transformer? Why does my power go out? How does the electric company know how much to charge? Why are some wires overhead and some underground? Where does electricity come from? Just how dangerous is it to climb transmission towers? The answers to these and other questions will be discovered in this TAM when you:

A. Visit and identify distribution equipment.

B. Construct a model distribution system.

C. Conduct laboratory experiments.

Activity Sequence:

1. Complete the pre-assessment quiz.
2. Complete the activities described in this TAM.

Key Information:

1. Class Presentations

Your instructor will make presentations on these topics:

- Basic electrical terms
- Generation of electricity and energy conversion
- Overview of an electrical distribution system
- Analysis of the function and appearance of individual components
- System reliability, line loss, and electrical safety

2. Demonstrations

- Use of test equipment
- Circuit construction

3. Safety - Major concerns

- Energized circuits
- Ground fault circuit interruptions
- Insulated flooring material
- Safety goggles

4. Personal Activity

Your instructor will direct you to reading assignments for background information which will help you get more out of the activities included in this TAM. One of the keys to getting something out of these activities is simply to become more aware of the electrical distribution equipment that is around you all the time.

Glossary:

1. **Amperage** -- The rate of electric (electron) flow.
2. **Electrocution** -- Death by electricity.
3. **Line Losses** -- The power consumed by a wire as it conducts electricity.
4. **Power Plant** -- A large energy conversion machine. Various sources of energy (stored water, coal, uranium) are converted to electrical energy.
5. **Resistance** -- The opposition to electron flow.
6. **Substation** -- A collection of interconnected devices where switching, voltage changing and metering take place.
7. **Transformer** -- An electrical device used to step up or step down voltage through electromechanical action.
8. **Voltage** -- Electrical pressure.
9. **Watt** -- A unit of energy; the product of voltage and amperage (P=IxE).

Needed Materials:

1. Supplies Required

A. Distribution System
- -Sketching supplies
- -Photographic film (optional)

B. System Modeling
- -Various modeling supplies
- -Hookup wire
- -(1) transformer 10:1 (300 VA)
- -(4-8) transformers 5:1
- -(8-20) six-volt light bulbs w/ sockets
- -4 x 8 sheet of plywood

C. Laboratory Experimentation
- -Wire of various sizes

2. Equipment/Machines/Tools

A. Distribution System
- -Camera (optional)
- -Variable AC power supply (0-30 VAC, 3A)

B. System Modeling
- -Test equipment (VOM)
- -Variable AC power supply (0-30 VAC, 3A)

C. Laboratory Experimentation
- -Power supplies
- -Light bulbs, etc
- -Multimeter (VOM)

3. Handouts

A. Distribution System
- -Student component of TAM #16
- -Sample Distribution Equipment
- -Distribution Identification Worksheet
- -Preassessment Quiz

B. System Modeling
- -Student component of TAM #16
- -Electrical Safety Handout
- -Distribution System Component Sample Handout

C. Laboratory Experimentation
- -Student component of TAM #16
- -Line Loss Fact Sheet

TAM #16: Electrical Distribution Model

Activity #1: Field Recognition - Plan of Procedure

1. In order to become more familiar with electrical distribution equipment, begin by reviewing the equipment pictured in Handout 1 - Distribution Equipment Identification Sheet.

2. Your instructor will give you specific instructions as to how he or she wants you to identify some equipment on your own. You may be asked to:
   A. Do it as a homework assignment
   B. Have your instructor lead the class
   C. Have an electric company representative lead a tour
   D. Visit a substation or power plant

3. On the Distribution Identification Worksheet (Handout 2), do some field sketches of the equipment specified. Be as detailed as you can in recording detail such as markings (on the pole or device), device location, size, height, shape, how it is wired, etc. You may attach photographs if you prefer (your instructor or an electric company representative will help you identify any component you are uncertain about).

4. Compare your sketches to others in class. Make note of how different perspectives and techniques can add to the clarity of sketches.

TAM #16: Electrical Distribution Model

Activity #2: System Modeling - Plan of Procedure

1. As a class, you are going to design and build a model electrical distribution system. (Figure #1).

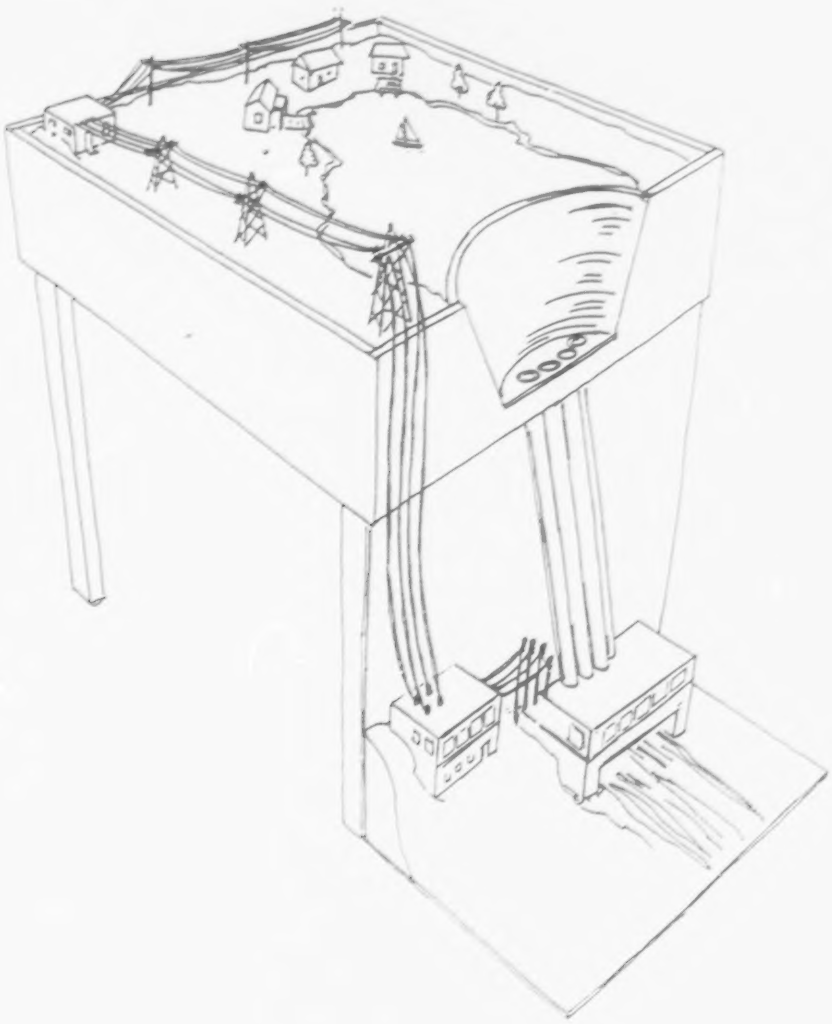


Figure #1 - Electrical Distribution System Model

2. Your distribution system will have, but not be limited to:

   A. One Step Up Substation - the type typically found at power plants. Many generators produce electricity at 20,000-30,000 volts. Before electricity leaves the power plant, it is typically stepped up to 138,000 V or 345,000 V. Your model substation will use a transformer to step up voltage from 12 V (the generator) to 120 V (transmission voltage).

   B. Two or more Distribution Substations - the type typically found in local neighborhoods. Since high voltage lines require wide easements and great towers, the voltage is usually stepped down in a distribution substation to lower voltage values (4,000-12,000 volts). These distribution lines may be overhead or underground and carry electricity into neighborhoods. Your model distribution substation will step down voltage from 120 V to 24 V. You may choose to incorporate some switches in your substation.

   C. Two or more Distribution Transformers - the type typically found in your front or back yard. A typical home is supplies with 120/240 volts. A distribution transformer is used to step the distribution voltage (4,000-12,000v) down to 120/240 volts. Distribution transformers may serve from one to ten different customers. In other words, several customers may "share", the transformer. Your model distribution transformer will step down voltage from 24 volts to 4.8 volts. This transformer may be pole mounted (overhead) or pad mounted (underground).

   D. Consumer units

   E. Distribution System - poles/cables

3. As you design your system, refer to the schematic representation in Figure #2.

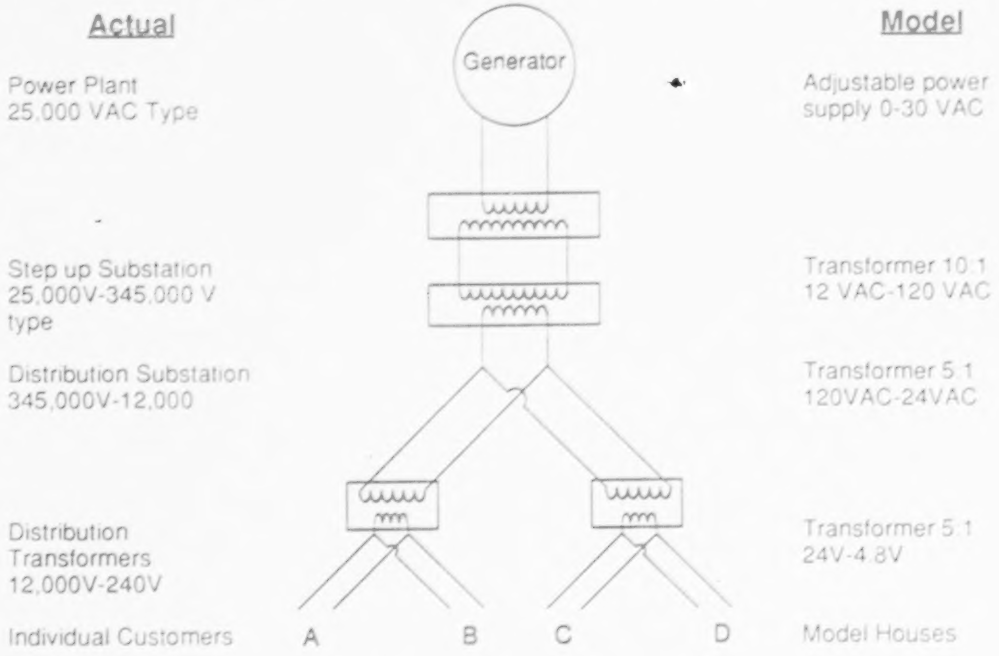

Actual
Model
Generator
Power Plant
25,000 VAC Type
Adjustable power supply 0-30 VAC
Step up Substation
25,000V-345,000 V type
Transformer 10:1
12 VAC-120 VAC
Distribution Substation
345,000V-12,000
Transformer 5:1
120VAC-24VAC
Distribution Transformers
12,000V-240V
Transformer 5:1
24V-4.8V
Individual Customers
A
B
C
D
Model Houses

Figure #2 - Schematic

4. Your instructor will divide the class into small work crews and assign your crew a specific territory. The crew will submit a design plan to the instructor and upon approval, the crew will construct their portion of the model. Your plan should contain, but not be limited to:
   - A. A distribution system
   - B. Overhead distribution poles
   - C. Underground distribution lines
   - D. Overhead (pole top) and underground (pad mount) distribution transformers
   - E. Attachment to a structure (at least one)

5. Have your instructor verify all electrical connections.

6. Energize the system and troubleshoot any problem areas.

7. Measure and record voltages in each stage of the system. Answer the following questions:
   - A. What happens to the service voltage when the voltage at the power plant is raised or lowered?
   - B. How many customers would be affected if a distribution transformer happened to overheat and fail?
   - C. How would you design your substations if you wanted to tie into another power plant or an adjacent service area?

TAM #16: Electrical Distribution Model

Activity #3: Line Loss Experiment - Plan of Procedure

1. Study the Line Loss Fact Sheet (Handout 3).
2. You are to design an experiment where you calculate line losses. See Figure #3 for one possible design.

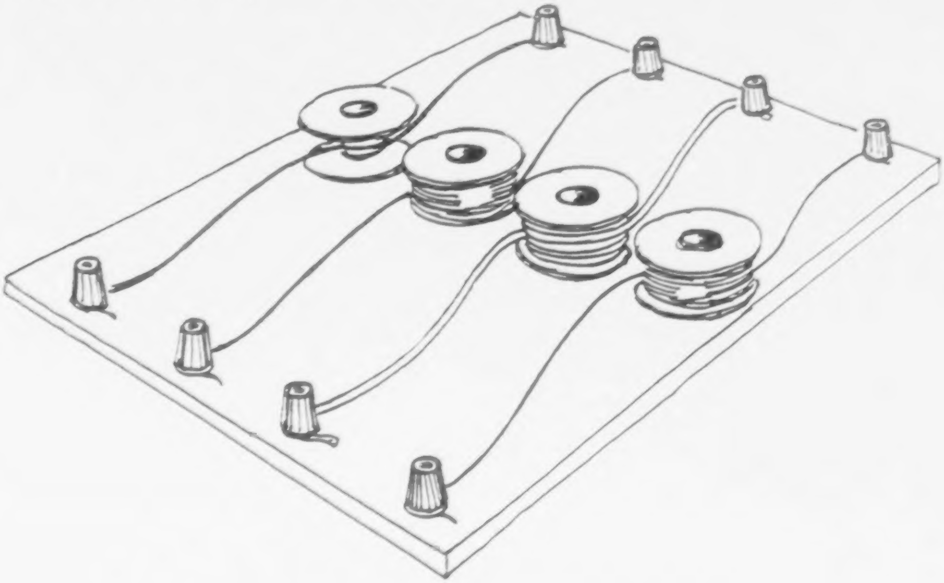


Figure #3 - Sample Experimental Setup

3. Your experiment may be designed to verify any of these concepts:
   - A. The longer the wire, the greater the losses.
   - B. The smaller the wire diameter, the greater the losses.
   - C. The greater the amperage, the greater the losses.
4. Some experimental building blocks may include:
   - A. Measuring the resistance of wire of various lengths.
   - B. Measuring the resistance of different diameter wire.
   - C. Calculating line losses of wire at various loads (4 amps, 20 amps, etc.).
5. Design your experiment and submit to your instructor a proposed plan of procedure.
6. Upon approval, conduct your experiment.
7. Document the results in a report and present it to the class.

TAM #16 - Summary

1. **Review & Summary Activities**

   In this TAM you have learned about the various components that comprise an electrical distribution system. A functional distribution system was completed when you assembled these components into a working model.

   Although an actual electrical distribution system is a little more complex, the principles remain the same. Electricity is transmitted at high voltage values to minimize line losses. Less wasted power means lower electrical rates for the customers.

2. **Review Questions -- Test yourself!**

   A. Why are different power plants and substations tied together?

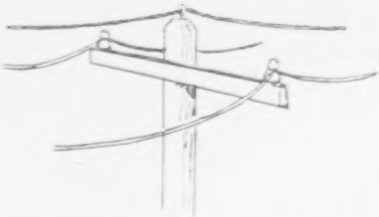
   B. Why are the principles of high voltage distribution not utilized in typical house wiring practices?

   C. How would transmission lines made of superconductors impact our society?

TAM #16 - Handout 1

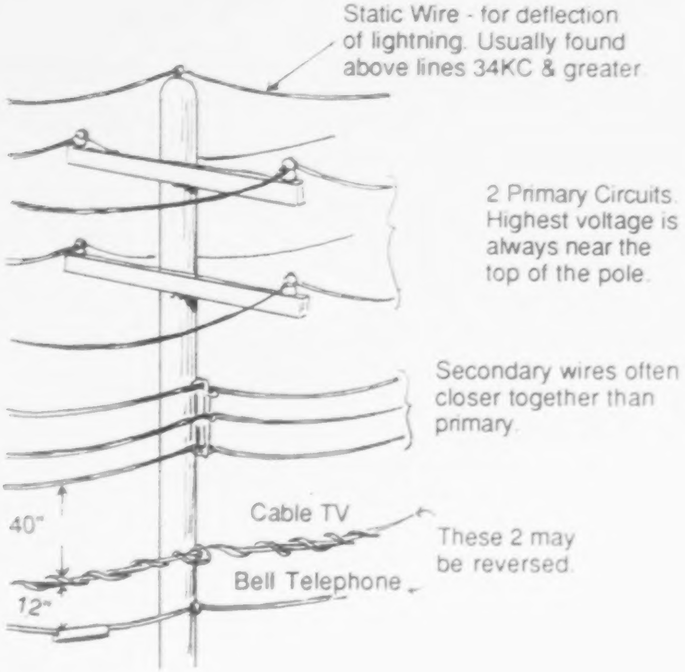
TAM #16 - Sample Distribution Equipment - Page #1

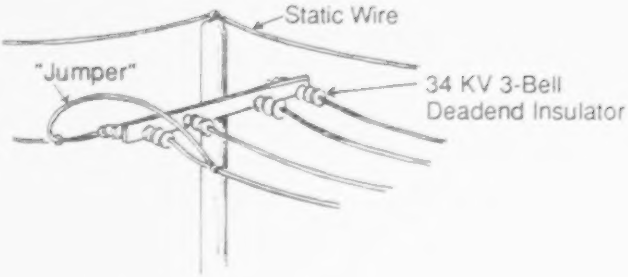
WIRES



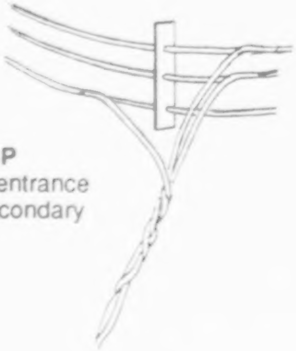
3 WIRES ON CROSSARM
Primary or Secondary

This method may use shorter poles than attaching directly to pole.


Static Wire - for deflection of lightning. Usually found above lines 34KC & greater.
2 Primary Circuits. Highest voltage is always near the top of the pole.
Secondary wires often closer together than primary.
40"
Cable TV
These 2 may be reversed.
Bell Telephone
12"


Static Wire
"Jumper"
34 KV 3-Bell Deadend Insulator

PRIMARY INSULATORS - "BELLS"
Wire voltage can usually be determined from the number of deadend insulators.
34 KV=3 Bells minimum
12 KV-2 Bells minimum
4 KV=1 Bell minimum
A jumper may be attached across deadend insulators to temporarily or permanently re-route a circuit.

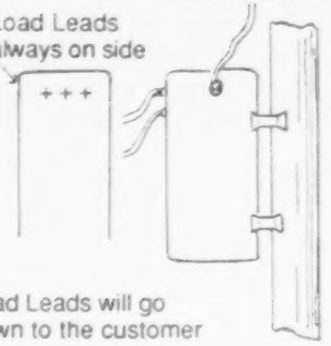


FLYING LOOP
Triplex service entrance comes off of secondary at mid-span.

TAM #16 - Handout 1 (continued)

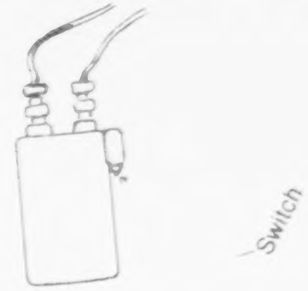
TAM #16 - Sample Distribution Equipment - Page #2

TRANSFORMERS

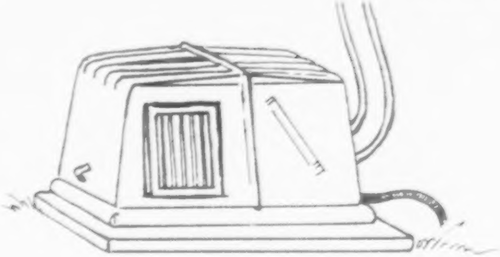

Line Lead (Primary)
Will go up.
Load Leads
always on side
+ + +
Load Leads will go
down to the customer

SINGLE PHASE (10)
2400V (4KV) Line Bushing is on the side of the transformer.
All transformers should be clearly marked in volts and/or KVA.

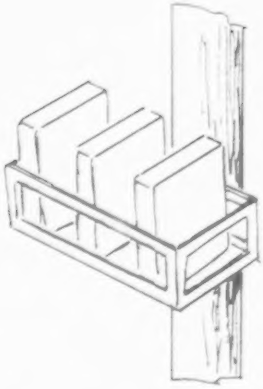
SPECIAL EQUIPMENT



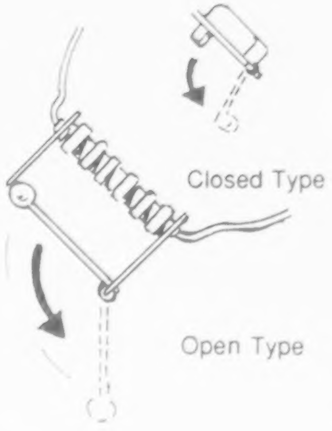
RECLOSER OR SECTIONALIZER
Reclosers are used in heavy tree areas to re-close switching when limbs touch lines. Similar in appearance to a transformer but there are only two leads which are always on top of the can. Sectionalizers are installed on taps and work in conjunction with reclosers.



Pad Mounted Underground Transformer



CAPACITORS
Rectangular boxes (usually clustered in groups of three) and used to counteract heavy inductive loads.


Closed Type
Open Type

FUSED SWITCH
When fuse blows, the switch will fall open (down). The ring is for the lineman's hot stick. Small transformers have interior fuses, but these are almost always found above 12 KV transformers.

TAM #16 - Handout 2

TAM #16 - Distribution Identification Worksheet

Transmission tower	Transformer - overhead
Transformer - pad mounted for underground service	High voltage transmission line - many insulators
Distribution pole with crossarms	Distribution line with one, two or three insulators
Lightning arrestors	Transmission pole - from overhead to underground

TAM #16 - Handout 3

TAM #16 - Line Loss Fact Sheet

Whenever electricity is passed through a conductor, some energy is consumed by molecular friction. This energy is given up in the form of heat and referred to as line losses.

Line losses can be calculated by using this formula:

$$P = I^2R$$

where:

P = Power lost in watts
I = Amperage in the line
R = Resistance of the line

Example: If a 10 mil length of line had 4 ohms of resistance and carried 50 amps, how many watts would be lost?

Solution

$P = I^2 \times R$
$P = 50 \times 50 \times 50$
P = 12,500 watts lost

The reason electricity is transmitted over long distances at a high voltage is because it will result in a lower current value. Consider these two large customers, each requiring 1 megawatt (1,000,000 watts).

Option A Low Voltage Transmission	Option B High Voltage Transmission
$P = I \times E$	$P = I \times E$
1,000,000 = 500 amps x 2,000v	1,000,000 = 83.3 amps x 12,000v

Next, calculate line loss.

Solution

The conductors serving this customer have a Resistance of 1 ohm.

P = I2 x R	P = I2 x R
P = 500 x 500x1	P = 83.3 x 83.3 x 1
P = 250,000 watts lost	P = 6,938 watts lost

TAM #16 - Handout 4

TAM #16 - Electrical Safety Handout

An electric shock is a physical sensation caused when your nerves react to electric current. In minor cases you will sense only a mild tingle or severe jerking. However, at higher current values, your heart and the muscles which control breathing may become paralyzed and result in death (electrocution).

To help minimize your exposure to electrical shock, follow these general safety rules and practices.

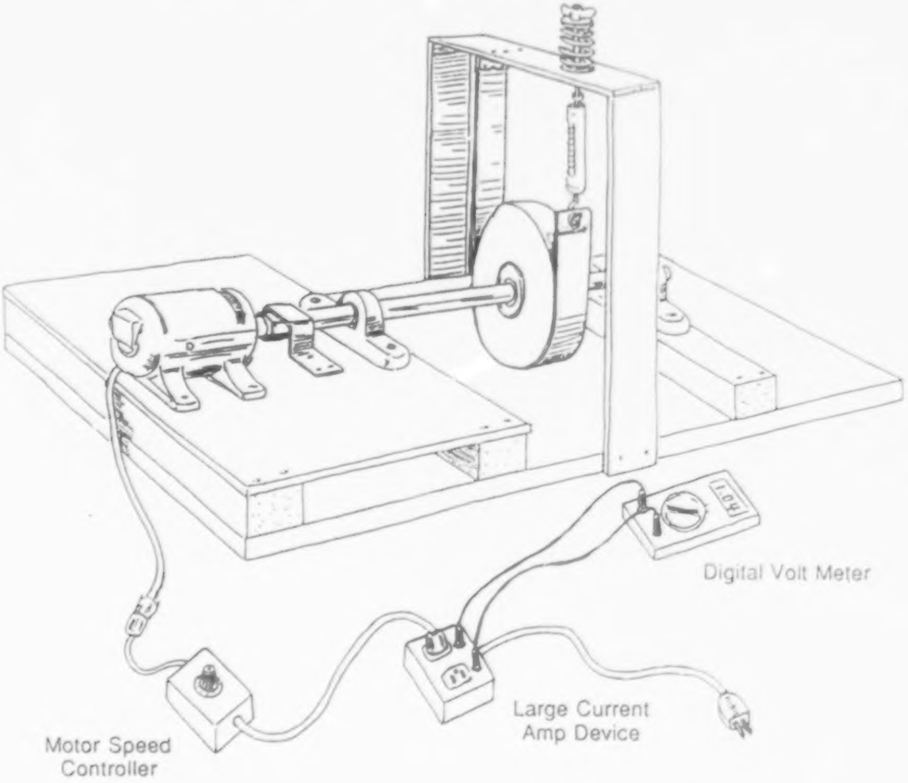
1. Treat all electrical wires in a circuit as being potentially dangerous.
2. Do not touch water or gas pipes, a sink or bathtub, or any wet surface while handling metal parts of an electrical appliance.
3. Learn to work on electrical equipment with one hand. This minimizes the likelihood of electrical shock.
4. Wear rubber-soled shoes or stand on an insulated floor mat when working with electrical devices.
5. Make it a habit to periodically inspect all the electrical appliances and tools you use. Watch for loose wires, frayed cords, and bare wires.
6. Do not work on any electrical equipment unless you know the right procedures to follow.
7. A Ground-Fault Circuit Interrupter (GFCI) is a device that gives added protection against electrical shock. It should be used to protect circuits where water may be present or the likelihood of electrical shock is great.
8. Whenever possible, do not work on energized circuits.

Course:	Introduction to Energy & Power Technology

Technology Activity Module #17

Applying Electric Motors

by: Lynn Diel


Digital Volt Meter
Large Current Amp Device
Motor Speed Controller

TAM #17: Applying Electric Motors

Instructor Component

Activity Objectives: The purpose of this activity is to expose the student to the various types of electric motors used in industry. The first activity will discuss how to wire and control these motors. The second activity will discuss how to change speed and direction as well as how to connect protection devices. The third activity will deal with testing motor output.

Activity Competencies: By completing this TAM, the student will be able to:

1. Define basic electrical terminology as it pertains to motors.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to motors.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operation of electric/electronic test equipment and tools.
4. Identify the hazards involved in wiring and controlling motors.
5. Use electronic components to construct a simple piece of test equipment.
6. Develop problem solving and creative abilities involving motors.
7. Identify the major types of motors and their parts.
8. Explain how protection devices work and the need for them.

Module Instructions

Introduction:

In Activity #1, a student (or group of students) will see how to wire and control a DC motor. They will do this by wiring and installing a latching relay to control a motor. In part B of the first activity, the student(s) will install a reversing switch to the circuit and test its operation. Activity #2 consists of assembling a motor speed control and demonstrating its principle with a light bulb and then a universal motor (e.g., a electric drill). In Activity #3, the students will learn how to measure the performance of a motor.

Safety Considerations:

Special attention must be paid when students work with any type of device that involves circular motion, such as a motor. When constructing any of the activities, the student should practice safe and proper work habits, i.e., proper use of hand tools and soldering equipment. Also, special precautions should be taken when working with circuits fed by 120 and 240 VAC.

Needed Materials:

1. **Supplies Required**

Activity One

A. 1 - DPDT relay (coil voltage 12 volt DC)
B. 1 - N.O. SPST Momentary Pushbutton Switch Radio Shack #275-1547
C. 1 - N.C. SPST Momentary Pushbutton Switch Radio Shack #275-15481
D. 1 - Permanent Magnet motor 12 volt DC (or equivalent - surplus motors)

Activity Two

A. 1 - DPDT switch Radio Shack #275-66

Parts list for variable speed control

A. 2 - 400 Volt 1 amp diodes 1N4004
B. 1 - 5.6K Ohm 2 watt resistor
C. 1 - 1K Ohm 2 watt potentiometer
D. 1 - 100K 1/4 watt resistor
E. 1 - 8 Amp 400 PIV silicon controlled rectifier
F. 1 - 1 inch square piece of aluminum .25 inch thick (heat sink)
G. 1 - Neon bulb and holder
H. 1 - AC line cord 3-wire
I. 1 - AC single receptacle
J. 1 - Fuse 3 amp "Slo-Blo" fuse (see discussion below in Prerequisite Information section)
K. 1 - Fuse holder
L. 2 - SPST switches 125 Volts 3 Amp
M. 1 - Project box 6 1/4" x 3 3/4" x 2" Radio Shack #270-627
N. 1 - 3/8" rubber grommet or strain relief

Parts list for Activity Three

A. 1 - Clamp-on Amp meter (optional)
B. 1 - Digital Volt Ohm Meter
C. 1 - 11 inch 10-gauge stranded wire
D. 1 - 4x4 electrical handy box complete with electrical single receptacle cover
E. 1 - Duplex electrical receptacle
F. 2 - 10 inch lengths of 16 gauge stranded wire
G. 2 - Banana jacks
H. 1 - power cord
I. 1 - Romex wire connector (to hold power cable)

2. **Equipment/Machines/Tools**

A. Low wattage light fixture (incandescent)
B. Electric hand drill
C. Soldering iron (25 Watt maximum)
D. 60/40 rosin core solder
E. Needle nose pliers
F. Wire cutter
G. VOM or DVM
H. Frequency counter

I. Oscilloscope
J. GFI (Ground Fault Interrupter) for safety

3. **Handouts**
   A. Student component of TAM #17

4. **Instructional Resources**
   A. Catalogs (construction equipment & materials)
      1. Kelvin Electronics
         7 Fairchild Avenue
         Plainview, NY 11803
      2. Mouser Electronics
         National Circulation Center
         P.O. Box 699
         Mansfield, TX 76063
      3. Radio Shack

   B. Books
      1. National Electrical Manufacturers Associations National Electrical Code
      2. Humphries & Sheets. Industrial electronics. Breton Publishers.
      3. Stone, Richard. Introduction to internal combustion engines. ISBN 0333375939

Management/Logistics:

1. **Related TAMS**

You may wish to refer to TAM #11 - Robot Control and TAM #18 - Using Electronic Instrumentation.

2. **Evaluation/Grading**
   A. Mastery check-off post-test.
   B. The quality of the finished project.
   C. Evaluate pre- and post-test taken by students.

3. **Suggested Schedule/Time**

The time suggested for this TAM is one to two weeks.

Key Instructional Suggestions:

1. **Safety**

Be sure that students are properly informed about the hazards of electrical shock in all activities. It is also important that they be properly informed of the hazards of circular motion of fans or motors. Have the school nurse give a short lecture on how to aid a victim of electrical shock.

2. **Motivation**

Demonstrate the principle of inductive kick (see Figure #1 on p. 9 of the instructor component) to help explain the theory of induction motors.

3. **Prerequisite Information**

When power is initially applied to a motor, there is an inrush of voltage (remember that voltage leads current in an inductive circuit), thereby causing a high current to be available. This current draw can be in excess of 125 percent of the running load. A "slo blow" fuse is a special protection device that allows this current to flow for a short period of time. If the high current demand does not subside the fuse will then open to protect the circuit. A typical scenario that you will undoubtedly run into is when a motor is jogged (started and stopped repeatedly). This method of jogging the motor is used when the operator is trying to synchronize an operation. During the jogging phase, the motor as well as the protection device is subject to large amounts of current flow. This sometimes causes the fuse to "age" (shorten the fuse's lifespan). If you encounter this type of operation you should either install another protection device that is rated at a 10 percent higher rating, or install a electrical breaker rated for motors.

4. **Demonstrations**

Demonstrations should be given on the following:

A. Inductive kick
B. How to read an electrical schematic
C. How to breadboard a circuit
D. How to use the test equipment used in this TAM

5. **Reinforcement**

This TAM provides an opportunity to reinforce basic principles of physics such as induction theory, Ohm's Law, and half-wave rectification.

6. **Attitudes**

The establishment of good safety attitudes should be one of the most important outcomes for Industrial Technology Education programs. Students usually come to the study of electricity with a healthy regard for its potential dangers. The instructor can use this awareness to extend discussions of safety into other application areas. Students will also see how careful circuit construction techniques and good housekeeping contribute to successful motor operation.

7. **Remediation/Enrichment**

Remediation: Repeat the initial demonstration. Pair up advanced students with those that are having trouble.

Enrichment: Have students explore the many uses of the electric motors in industry. Have students explore the many uses for the new technology of Programmable Logic Controllers.

8. **Summary & Review**

In this TAM, students will have constructed a means to electrically latch a motor in the on position. In the second part of this activity we wired a reversing switch to the circuit. In Activity #2, they will have been shown how to vary the speed and provide protection to an electric motor. In Activity #3, they will have been shown how to test an electric motor to describe and measure its performance.

9. **Review Questions & Answers**

   A. An electrical device that protects the motor and wiring if too much current is flowing is called a _____________. (*fuse*)

   B. A universal motor will operate on ____________________. (*both AC and DC*)

   C. The main reason for testing the amperage of a motor is to ____. (*determine if the motor is operating properly*)

Date: ________ Class: ________ Name: ____________________________

TAM #17: Applying Electric Motors - Pre-test

A. An electrical device used to measure the current of an Alternating Current motor (AC) is called an ______________________.

B. A universal motor is unique in that it uses _______________ to connect the rotor to the power source.

C. A single phase inductive motor that uses a capacitor to create a phase shift, thereby inducing a current in the rotor, is called a ___________________ _____________________.

D. An _______________________ ___________________ is an alternating-current motor in which the primary winding (stator) is connected to the line voltage and induces a current in secondary (rotor).

E. The amount of force that a motor develops is referred to as ______________________ ____________________.

F. The part of the motor structure that turns which is usually connected to the main shaft is called a ______________________.

G. A series wound motor designed to operate at the same speed and current on either alternating current or direct current is called a ___________________ ____________________.

Date: ________ Class: ________ Name: ____________________________

TAM #17: Applying Electric Motors - Post-test

Directions: Evaluate the student by checking the appropriate letter to indicate the degree of competency.

Rating Scale:
^ **Mastered -** has performed task satisfactorily
0 **Not Mastered -** has not performed the task satisfactorily
v **No Exposure -** no experience or knowledge in this area

^ 0 v Identify electrical hazards

^ 0 v Identify and practice shop safety

^ 0 v Identify and practice safe soldering methods

^ 0 v Demonstrate safe and proper use of hand tools

^ 0 v Demonstrate safe and proper use of AC line equipment, i.e., Ground Fault Interrupter (GFI)

^ 0 v Identify the hazards of rotational devices

^ 0 v Describe the operation of an electrical contactor

^ 0 v Describe the operation of a latching relay

^ 0 v Describe the operation of a reversing switch

^ 0 v Identify how motors are rated

^ 0 v Demonstrate proper soldering techniques in board construction

^ 0 v Demonstrate proper construction techniques in circuit board construction, i.e., proper component handling

^ 0 v Demonstrate proper breadboard techniques in circuit construction

^ 0 v Describe the operation of a slo blow fuse

TAM #17: Applying Electric Motors - Test Keys

TAM #17 - Pre-test Answers

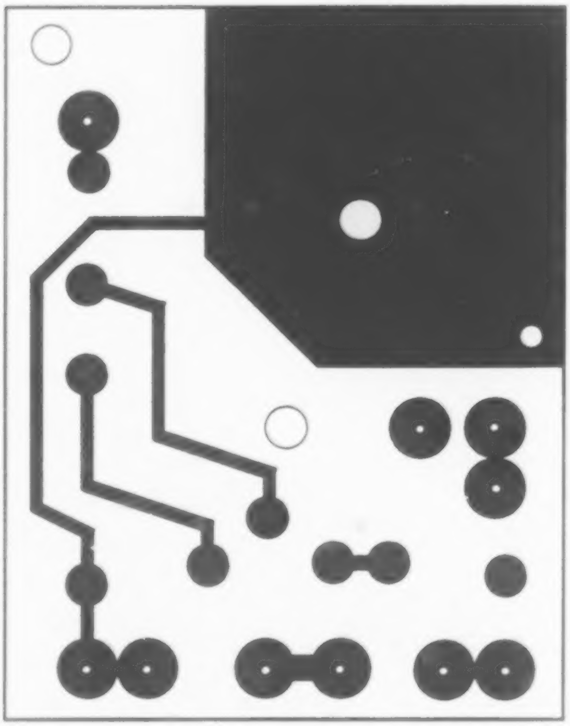
A. Amp meter
B. Brushes
C. Capacitor Motor
D. Induction Motor
E. Motor Torque
F. Rotor
G. Universal Motor

TAM #17 - Post-test Answers

Post-assessment will be determined by completing the competency evaluation sheet for each student.

TAM #17: Applying Electric Motors

PC Board Artwork



Motor Controller Artwork Positive

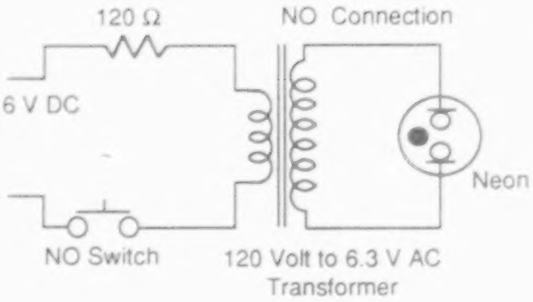
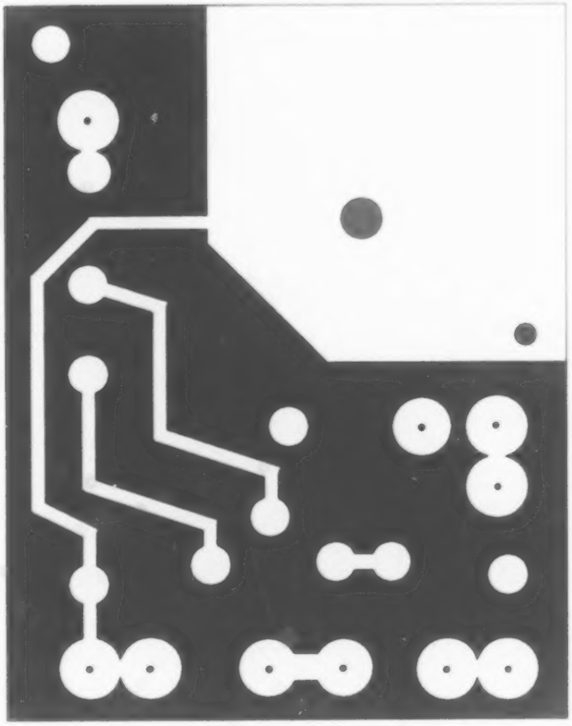

120 Ω
NO Connection
6 V DC
Neon
NO Switch
120 Volt to 6.3 V AC
Transformer

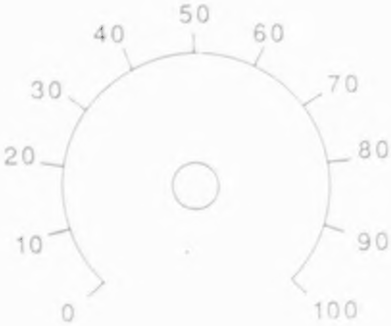
Figure #1 - Inductive Kick Schematic

TAM #17: Applying Electric Motors

PC Board Artwork



Motor Controller Artwork Negative


0
10
20
30
40
50
60
70
80
90
100

Speed Dial Indicator

TAM #17: Applying Electric Motors

Student Component

Introduction:

Industry would be motionless without the aid of motors. This device is probably the single most important device currently in use to convert electrical energy to mechanical energy. Everywhere you turn, you may see the evidence of motors in heating and cooling, mixing chemical, conveyors and many other devices.

Competencies: Following the completion of this TAM, you will be able to:

1. Define basic electrical terminology as it pertains to motors.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to motors.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operation of electric/electronic test equipment and tools.
4. Identify the hazards involved in wiring and controlling motors.
5. Use electronic components to construct a simple piece of test equipment.
6. Develop problem solving and creative abilities involving motors.
7. Identify the major types of motors and their parts.
8. Explain how protection devices work and the need for them.

Module Overview:

This module contains three activities which are designed to help you increase your knowledge about electric motors. You will have an opportunity to learn how to wire and control motors, including adjustments for speed and direction control as well as how to test output. The activities are wiring and controlling motors, speed/direction/protection of motors, and testing motor output.

Activity Sequence:

1. Participate in the instructor's demonstration for this TAM. Follow all instructions, e.g., reading the assigned material and reviewing the procedural steps.
2. Complete the pre-test given by the instructor.
3. Do Activity #1 -- Wiring and Controlling Motors.
4. Do Activity #2 -- Speed, Direction, and Protection of Electric Motors
5. Do Activity #3 -- Testing Motor Output.
6. Review the material and summarize in your own words.
7. Complete the post-assessment procedure.

Key Information:

1. **Class Presentations**
    - The distinction between universal and inductive motors
    - The importance of speed, direction, and protection of motors
    - The variety of motors available
    - Identify some uses for motors

2. **Demonstrations**
    - Soldering techniques
    - Wiring an electric motor
    - Testing an electric motor

3. **Safety - major concerns**
    - Electric shock
    - Proper hand tools usage
    - Proper soldering techniques
    - Staying clear of rotational devices

4. **Personal Activity**

    As your homework, go to the library and look up some information about some of the pioneers of electric motors. Some good examples are Nikoli Tesla, George Westinghouse, and others.

    You may also want to visit a local manufacturing plant to see how speed, direction, and the protection of motors are foremost for production.

Glossary:

1. **Capacitor Motor** -- A single phase inductive motor that uses a capacitor to create a phase shift, thereby inducing a current in the rotor.
2. **Induction Motor** -- An alternating-current motor in which the primary winding (stator) is connected to the line voltage and induces a current in secondary (rotor).
3. **Locked Rotor Current** -- In a motor, the steady state current read from the line while the motor is locked and the rated voltage is applied.
4. **Motor Torque** -- The amount of force that a motor develops.
5. **NEMA** -- National Electric Manufacturers Association.
6. **Rotor** -- The part of the motor structure that turns; usually connected to the main shaft.
7. **RPM** -- Revolutions per minute.
8. **Shaded Pole Motor** -- A single phase motor that has one or more auxiliary short-circuited stator windings that magnetically displace the primary winding.
9. **Solder** -- An alloy of tin and lead.
10. **Stator** -- The non-rotating part of an induction motor; usually contains the primary windings.
11. **Universal Motor** -- A series wound motor designed to operate at the same speed and current on either alternating current or direct current.

Needed Materials:

1. **Supplies Required**

   Activity One

   A. 1 - DPDT relay (coil voltage 12 volt DC)
   B. 1 - N.O. SPST Momentary Pushbutton Switch Radio Shack #275-1547
   C. 1 - N.C. SPST Momentary Pushbutton Switch Radio Shack #275-15481
   D. 1 - Permanent Magnet motor 12 volt DC (or equivalent - surplus motors)
   E. 1 - DPDT switch Radio Shack #275-66 (for Activity #2)

   Parts list for variable speed control

   A. 2 - 400 Volt 1 amp diodes 1N4004
   B. 1 - 5.6K Ohm 2 watt resistor
   C. 1 - 1K Ohm 2 watt potentiometer
   D. 1 - 100K 1/4 watt resistor
   E. 1 - 8 Amp 400 PIV silicon controlled rectifier
   F. 1 - 1 inch square piece of aluminum .25 inch thick (heat sink)
   G. 1 - Neon bulb and holder
   H. 1 - AC line cord 3-wire
   I. 1 - AC single receptacle
   J. 1 - Fuse 3 amp "Slo-Blo" fuse (see discussion below in Prerequisite Information section)
   K. 1 - Fuse holder
   L. 2 - SPST switches 125 Volts 3 Amp
   M. 1 - Project box 6 1/4" x 3 3/4" x 2" Radio Shack #270-627
   N. 1 - 3/8" rubber grommet or strain relief

   Parts list for Activity Three

   A. 1 - Clamp-on Amp meter (optional)
   B. 1 - Digital Volt Ohm Meter
   C. 1 - 11 inch 10-gauge stranded wire
   D. 1 - 4x4 electrical handy box complete with electrical single receptacle cover
   E. 1 - Duplex electrical receptacle
   F. 2 - 10 inch lengths of 16 gauge stranded wire
   G. 2 - Banana jacks
   H. 1 - power cord
   I. 1 - Romex wire connector (to hold power cable)

2. **Equipment/Machines/Tools**

   A. Low wattage light fixture (incandescent)
   B. Electric hand drill
   C. Soldering iron (25 Watt maximum)
   D. 60/40 rosin core solder
   E. Needle nose pliers
   F. Wire cutter
   G. VOM or DVM
   H. Frequency counter
   I. Oscilloscope
   J. GFI (Ground Fault Interrupter) for safety

3. **Handouts**

   A. Student Component of TAM #17

Activity #1: Wiring and Controlling Motors - Plan of Procedure

1. Breadboard the following circuit (Figure #2). For a printed circuit board, check with the instructor.

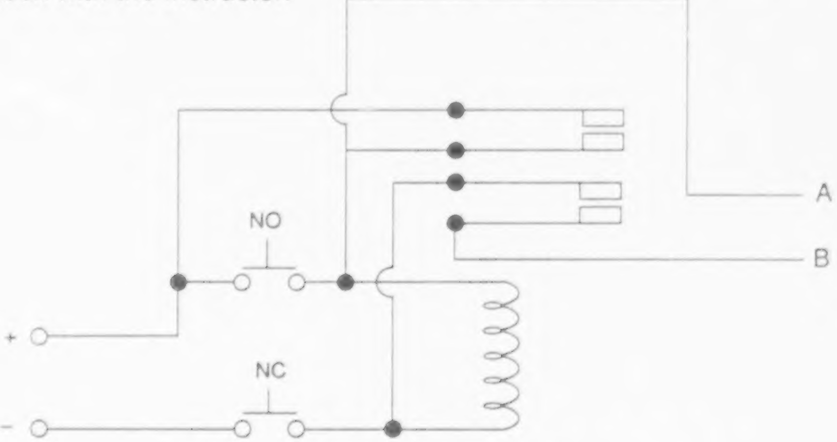
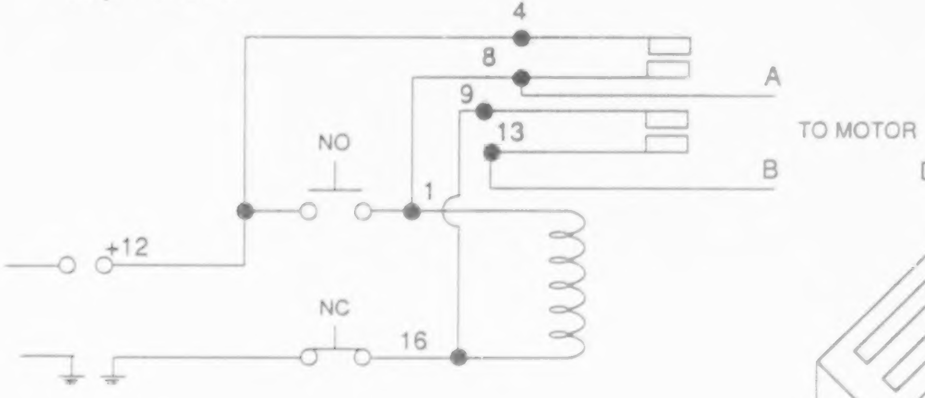


Figure #2 - Latching Relay Schematic

2. Construct the latching relay circuit (Figure #3). Note: This circuit is used only for the Mouser supplied DIP Relay. For all others see Figure #2 in step 1 above.



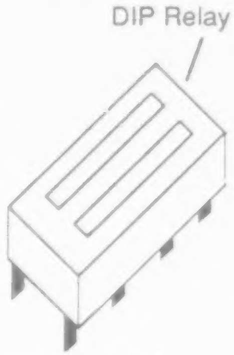


Figure #3 - Latching Relay Circuit Diagram

3. Select the 25volt DC range on the analog meter or 20-volt range on the digital volt meter. Turn on the Volt meter if needed.

4. Connect the plus lead of the volt meter to the plus lead of the power supply. Connect the negative lead of the volt meter to the minus of the power supply. Turn on the power supply and adjust the output to 12 Volts DC.

5. Turn off the power supply for now. Connect the wire at point A to one lead of the motor. Connect the wire at point B to the other lead of the motor. Connect the the wire at point P to the plus lead of the power supply. Connect the wire at point M to the minus lead of the power supply. Turn on the power supply.

   NOTE: If the motor starts to turn, turn off the power supply and recheck the wiring.

6. Now press switch one (SW1) momentarily. The motor should start running and continue to run when you remove your finger from switch one.
7. Now press switch two (SW2) momentarily. The motor should stop and remain off when you remove your finger from the switch.
8. Move the circuit aside for now.

Discussion

This simple circuit demonstrates a very important device used in industry to control electrical motors. This circuit is a low power equivalent to what is called an electrical contactor. Electrical contactors are used wherever motors are operated. In industry, other sensors (e.g., limit switches, proximity detectors, safety cutoff, etc.) are wired in parallel to the stop switch. This allows the motor to be controlled by the operation of the equipment as well as the operator.

When power is initially applied to a motor, there is an inrush of voltage (remember that voltage leads Current in an inductive circuit), thereby causing a high current to be available. This current draw can be in excess of 125 percent of the running load. A "slo blow" fuse is a special protection device that allows this current to flow for a short period of time. If the high current demand does not subside, the fuse will then open to protect the circuit. A typical scenario you will undoubtedly run into is when a motor is jogged (started and stopped repeatedly). This method of jogging the motor is used when the operator is trying to synchronize an operation. During the jogging phase the motor as well as the protection device is subject to large amounts of current flow. This sometimes causes the fuse to "age" (shortens the fuse's lifespan). If you encounter this type of operation you should either install another protection device that is rated at a 10 percent higher rating, or install a electrical breaker rated for motors.

9. Construct the following circuit (Figure #4).

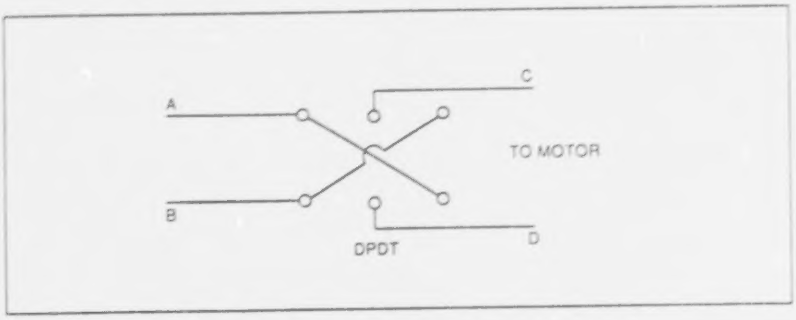


Figure #4 - Motor Reversing Schematic

10. Disconnect the motor wires labeled A and B from the breadboard. Next connect Switch three (SW3) wire A to point A and Switch three (SW3) wire B to point B of the breadboard.

11. Connect one wire of the motor to point C of Switch three (SW3) and the remaining wire of the motor to point C of Switch three (SW3). Turn on the power supply. **NOTE**: If the motor starts to turn, turn off the power supply and recheck the wiring.

12. Now press switch one (SW1) momentarily. The motor should start running and continue to run when you remove your finger from switch one. Now press switch two. The motor should stop and remain off when you remove your finger from the switch.

13. Now move the lever of Switch three (SW3) to the other position. Turn on the power supply and press switch one (SW1) momentarily. The motor should now be turning in the opposite direction.

    Discussion: This addition to the latching relay (electrical contactor) allows the direction of the motor to be changed. By replacing Switch three (SW3) with a DPDT relay, we could then use an electrical switch at a remote area to reverse the motor. In industry, the circuitry would be a little more complex, since the motor would need to be disconnected from the power source and stopped before the reversing would take place. This would be necessary to reduce the load on the motor and power supply.

Activity #2: Controlling the Speed, Direction, and Protection of Electric Motors - Plan of Procedure

1. Construct the following circuit on a printed circuit board (Figure #5). For the printed circuit board, see your instructor.

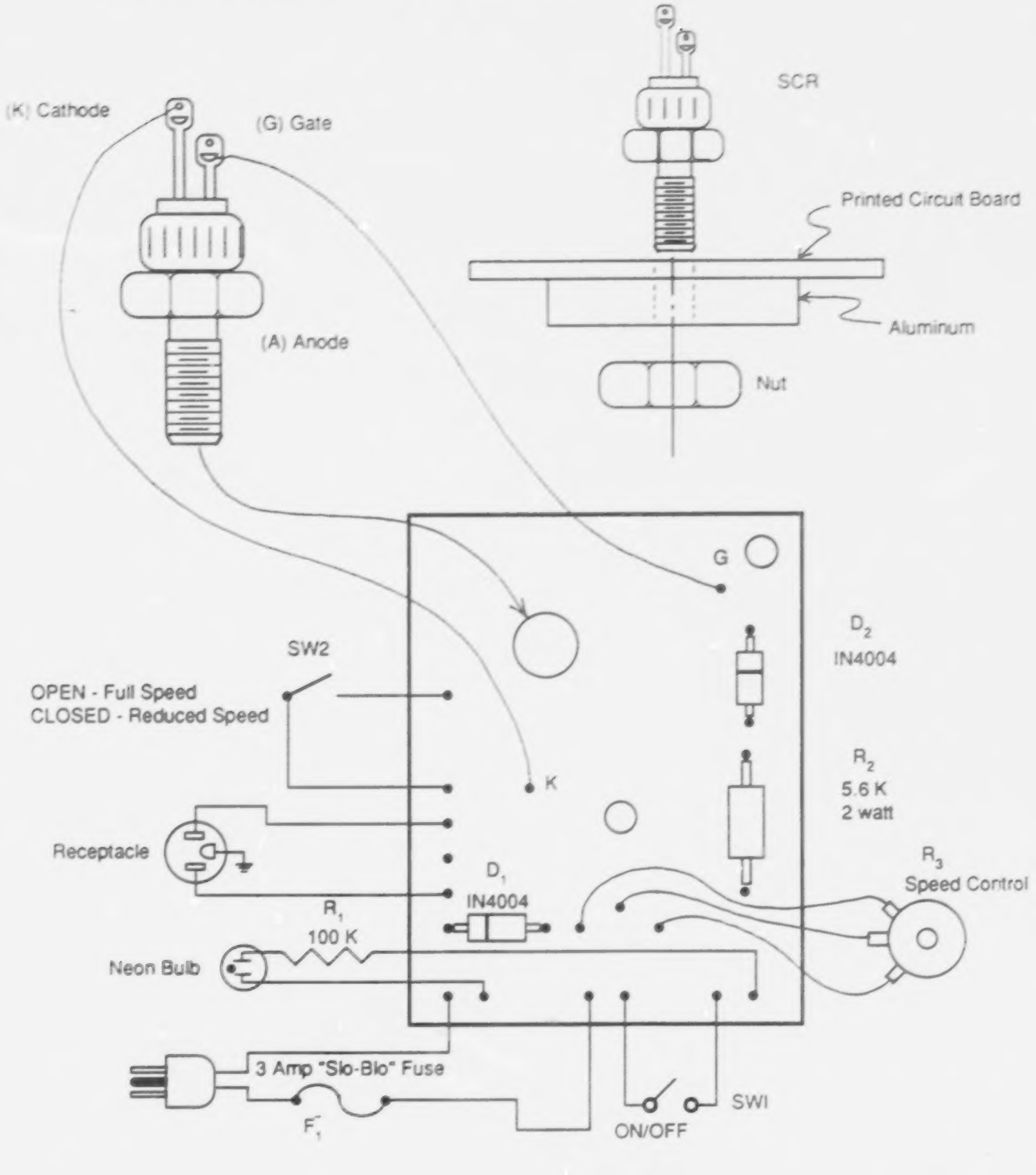

(K) Cathode
(G) Gate
(A) Anode
SCR
Printed Circuit Board
Aluminum
Nut
G
K
SW2
OPEN - Full Speed
CLOSED - Reduced Speed
D_2
IN4004
R_2
5.6 K
2 watt
Receptacle
D_1
IN4004
R_1
100 K
R_3
Speed Control
Neon Bulb
3 Amp "Slo-Blo" Fuse
F_1
SWI
ON/OFF

Figure #5 - Motor Speed Parts Placement

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2. Schematic diagram for the speed control circuit (Figure #6).

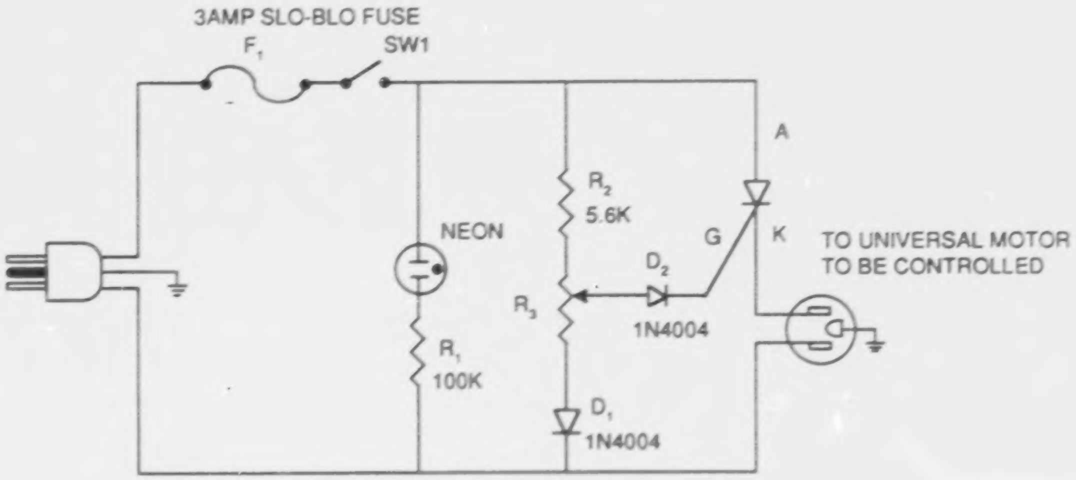


Figure #6 - Speed Control Schematic

3. Mount the printed circuit board inside a plastic housing. Take care not to short out any of the wires.

4. Before continuing, have the instructor check the soldering or the circuit layout for safety.

5. Turn potentiometer R3 fully Counter-Clockwise.

6. Check that the Power switch is in the OFF position.

7. Check that the Reduce/Direct switch is in the Direct position.

8. Set the Volt-Ohm-Meter to Rx1 scale.

9. Connect the Plus lead of the VOM to one lead of the line cord (see figure 6).

10. Connect the minus lead of the VOM to the other lead of the line cord.

11. If the meter reads less than infinity [0<] then recheck the wiring.

12. If the meter reading is infinity then proceed.

13. Toggle Switch 2 from Direct to Reduce.

14. Read the meter. Again if the meter reads less than infinity recheck the wiring.

15. If the meter reads infinity, then proceed.

16. Plug a low wattage light fixture (incandescent only) into the receptacle.

17. Plug the speed reducer into the GFI (ground fault interrupter) circuit.

18. Turn switch (SW1) to the on position. The light should come on at a very dim level.

19. Rotate potentiometer R3 slowly clockwise and note that the intensity of the light increases.

20. Now flip switch SW2 from Reduce to Direct and note that the light is at full brightness.

21. Turn switch SW1 to the OFF position.

22. Remove the low wattage light fixture from the receptacle.

23. Plug an electric hand drill into the receptacle.

24. Lock the electric hand drill's power to the on position.

25. Toggle switch SW2 to Reduce.

26. Rotate Potentiometer R3 fully counter-clockwise.

27. Turn on switch SW1. Note that the drill is operating at slow speed.

28. Rotate potentiometer R3 slowly clockwise. Note that the drill's speed increases.

29. Toggle switch SW2 to the Direct setting. Note that the drill operates at full speed.

Discussion

Since the majority of universal motors is designed to provide a single speed operation this circuit allows the user to vary the motor's speed. In this circuit, the SCR (silicon controlled rectifier) is used as an closed loop control device. Since the SCR is a half-wave device, it only supplies power during half the cycle. This produces a power and speed loss in the universal motor (hence the reason for the Reduce/Direct switch). During the half-cycles when the motor is off, there is a back EMF (electromotive force) which is sensed by the SCR. This is then used to change the gating of the next pulse automatically. The diode/resistor network provides for a 90° phase shift. This allows the device to provide high torque at reduced speeds. At low speeds the circuit goes into an alternate cycling mode where power is pulsed to suit motor loading conditions.

TAM #17: Applying Electric Motors

Activity #3: Testing Motor Output - Plan of Procedure

1. Construct the following circuit and install it inside a 4x4 "handy box" (Figure #7).

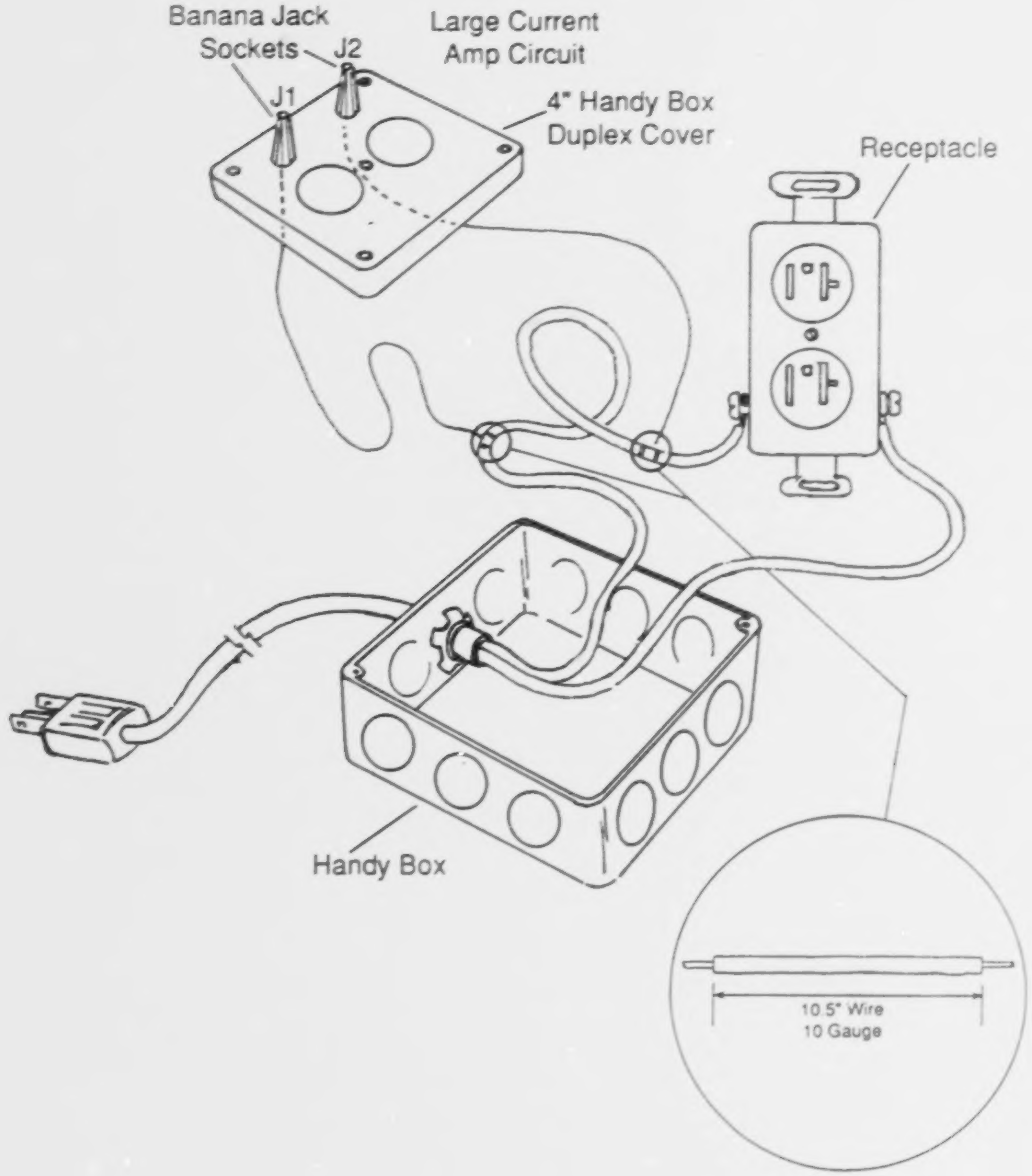

Banana Jack
Sockets
J2
J1
Large Current
Amp Circuit
4" Handy Box
Duplex Cover
Receptacle
Handy Box
10.5" Wire
10 Gauge

Figure #7 - Large Current Amp Circuit

2. Schematic diagram for Large Current Amp device (Figure #8).

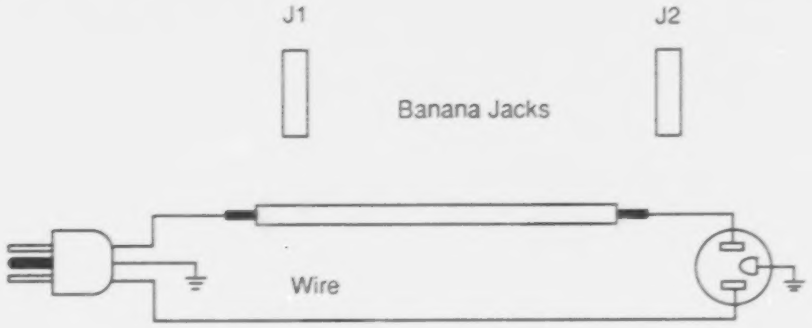


Figure #8 - Large Current Amp Device Schematic

3. Before continuing, have the instructor check the assembly and circuit layout for safety. To measure the performance of a motor in this activity, we will use a Large Current Amp (LCA) device in conjunction with a Digital Volt Meter.

4. With the Large Current Amp device disconnected from the AC electrical circuit, perform the following steps. Set the DVM to the Rx1 scale. Take the minus lead of the DVM ohmmeter and connect it to the center pin of the AC line cord of the LCA. Take the positive lead of the DVM ohmmeter and touch the metal case of the 4x4 handy box. It should read zero (0) ohms. **NOTE**: If the meter does not read zero (0) ohms, check to make sure the earth grounds are connected.

5. Take the positive lead and insert it into one side of the AC receptacle of the LCA. It should read infinity. **NOTE**: If the meter reads less than infinity, RECHECK the wiring and remove any shorts.

6. Now move the positive lead to the other side of the receptacle. It should read infinity. Set the Voltmeter to the 200 millivolt AC scale. Plug the positive lead of the voltmeter into J1 and the negative lead of the voltmeter into J2. Next, plug the motor to be tested into the receptacle of the LCA and the LCA into the (protected) AC wall receptacle. Turn the motor on and read the Voltage drop on the DVM.

   Discussion: The 10.5 inch wire has a resistance of .001 Ohm. Given this we can use Ohms Law to determine the amount of voltage drop in relation to current passing through the wire. **(Ohm's Law E=I R, so ...I = E / R)**

   So, in our circuit we know the resistance (R), and we can find E by reading the DVM. Let's assume that the reading of the DVM is .001 volt. Given this, we can plug into the formula

   $I = .001 / .001$
   $I = 1$

This then indicates a 1 amp current. The accuracy of this device will depend on how accurately the wire is cut and how the banana jacks are installed. If a Lab model amp meter is available the device can be calibrated. The overall accuracy is within ±4%.

7. If a dynometer (brake) is available, take a motor (i.e., electric hand drill) and measure the current draw of the motor as you increase the load on the motor (Figure #9). **NOTE**: Take proper precautions to prevent stalling the motor.

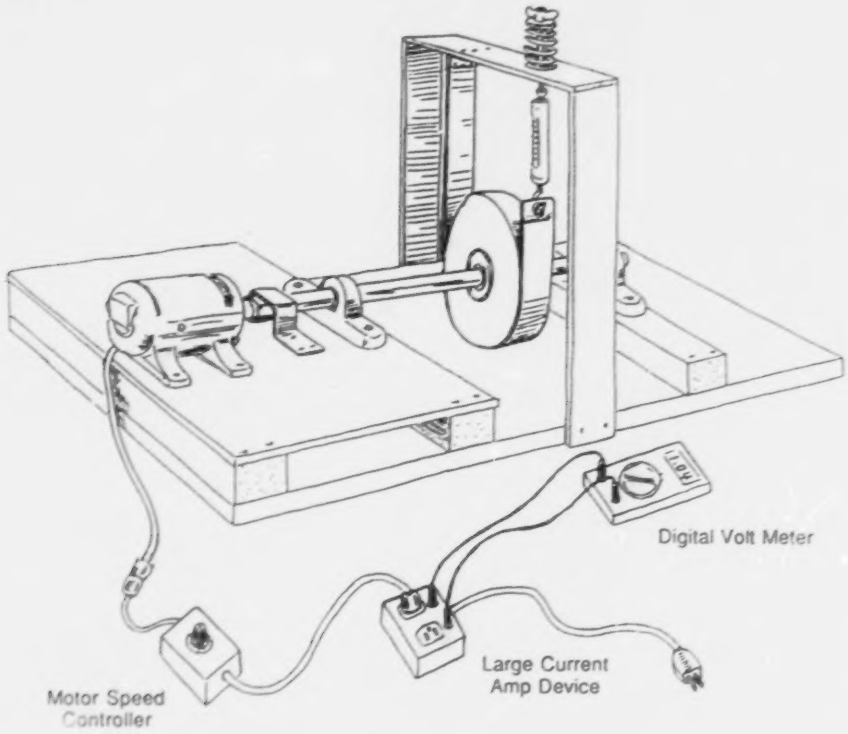


Figure #9 - Motor Tester

Discussion

As you increase the load on the motor, the work done by the electrical conversion to mechanical energy will start to be lost to heat. This heat is the major cause in motor failure. If you increase the load until the motor stops, the motor draw will go exceptionally high and blow the protection device. This is the Locked Rotor state, and the current drawn during this time is the Locked Rotor Amperage. This is usually given on the information plate on the side of back of the motor. Depending on the horsepower rating of the motor, this rating could be as high as 200-300 amps.

8. Record this data on a sheet of paper. Plot the data on a X-Y chart with load on the Y-axis and the amperage on the X-axis. From this graph pick what you think is the optimum load for the motor.

TAM #17 - Summary

The electric motor is one of the main work-horses of industry. Your ability to understand and work with them will prepare you to ensure that they operate at their maximum efficiency. These activities that you have completed in this TAM are but a small sample of the diversity you will encounter in industry.

1. **Reveiw & Summary Activity**

Calibration of Large Current Amp (LCA) (Optional)

A. To calibrate, connect the LCA and the Lab Amp meter in parallel to each other.

B. Turn on the load device.

C. Read the LCA and compare it to the Lab Amp meter.

D. If the LCA reads higher than the Lab Amp meter turn the power off and move J1 closer to the Receptacle (try 1 inch).

E. Turn on the load device.

F. Read the LCA and compare it to the Lab Amp meter.

G. If the LCA reads higher, repeat step D.

H. If the LCA reads lower, then turn the power off to the Load device and move J1 farther away from the receptacle.

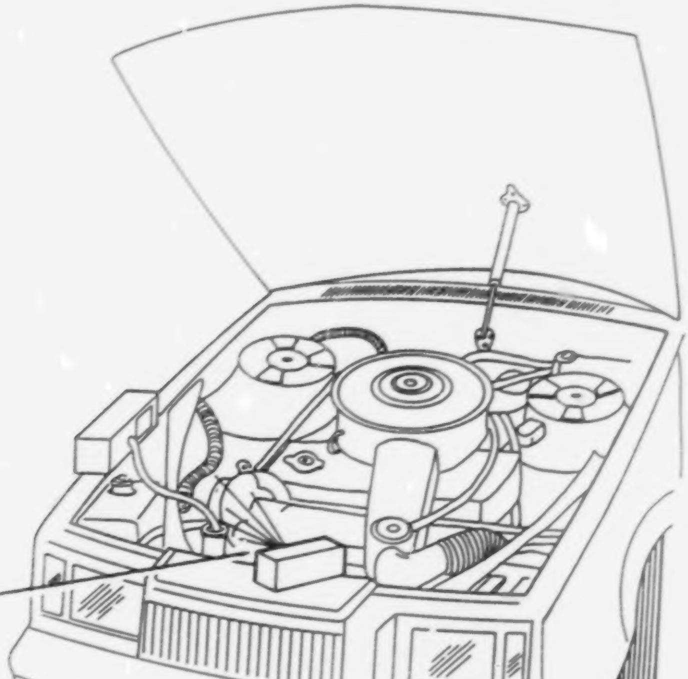
I. Repeat steps D through H until the LCA reads the same as the Lab Amp meter.

Course:	Introduction to Energy & Power Technology

Technology Activity Module #18

Using Electric Instrumentation

by: Lynn Diel



TAM #18: Using Electronic Implementation

Instructor Component

Activity Objectives: The purpose of these activities is to expose the student to several devices that are commonly used in instrumentation. The first activity consists of temperature measurement. The second activity uses a frequency strobe light to determine the speed of a motor.

Activity Competencies: By completing this TAM, the student will be able to:

1. Define basic electrical terminology as it pertains to instrumentation.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to instrumentation.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operations of electric/electronic test equipment and tools.
4. Identify the hazards involved in connecting instrumentation to equipment.
5. Use electronic components to construct a series of simple test equipment.
6. Differentiate between static and dynamic testing of equipment.
7. Differentiate between direct and remote connections of test equipment.

Module Instructions

Introduction:

In Activity #1 of the TAM a student (or group of students) will construct an electronic thermometer. The student will learn how to calibrate and use the instrumentation he or she has constructed. Activity #2 of this TAM requires a student or group of students to construct a electronic counter consisting of a strobe light which will then be used in conjunction with a frequency counter or oscilloscope to measure the speed of a motor.

Safety Considerations:

Special attention must be paid when students are working with devices using circular motion, such as fans. When constructing either of the devices the student should practice safe and proper work habits, i.e. proper use of hand tools and soldering equipment.

Needed Materials:

1. **Supplies Required**
   A. Parts list for a Fahrenheit Thermometer
      1. 1 - 33K Ohm 1/4 watt resistor
      2. 1 - 82K Ohm 1/4 watt resistor
      3. 1 - 56K Ohm 1/4 watt resistor

    4. 1 - 49K Ohm 1/4 watt resistor
    5. 1 - 220K Ohm 1/4 watt resistor

B. Parts list for a Celsius Thermometer
    1. 1 - 33K Ohm 1/4 watt resistor
    2. 2 - 120K Ohm 1/4 watt resistor
    3. 1 - 68K Ohm 1/4 watt resistor
    4. 1 - 220K Ohm 1/4 watt resistor

C. Parts list common for both
    1. 1 - 1K 10-turn potentiometer
    2. 1 - 10K 10-turn potentiometer
    3. 1 - 0.01 uF capacitor
    4. 1 - 1N4148 signal diode or equivalent
    5. 1 - LM317 adjustable regulator
    6. 1 - 1 uF electrolytic or tantalum capacitor 15WVDC
    7. 1 - 0.1 uF capacitor
    8. 1 - 240 Ohm 1/4 watt resistor
    9. 1 - 5K 10-turn potentiometer
    10. 72 inches - 20-24 gauge stranded wire or 36 inches of Belden 9239 Low noise coaxial cable or equivalent

D. Miscellaneous parts list for thermometers
    1. Crushed ice or ice cubes
    2. Glass thermometer (or equivalent)
    3. Styrofoam cups
    4. Container to hold boiling water
    5. Hot plate or other device capable of producing enough heat to boil water

E. Parts list for Strobe Counter

(NOTE: The following components are available from Kelvin Electronics. The following parts are included in Kelvin part number 840208)

    1. 1 - 1K Ohm 1/2 watt resistor
    2. 2 - 22 MFD capacitor 450WVDC
    3. 2 - iN4004 diodes
    4. 1 - 1Meg Ohm 1/4 watt resistor
    5. 1 - 500K potentiometer panel mount
    6. 1 - 0.47 uF capacitor 250WVDC
    7. 1 - SCR
    8. 1 - Trigger transformer
    9. 1 - Xenon strobe flash neon bulb
    10. 1 - push button switch
    11. 1 - power cord
    12. 24 inches of solid wire
    13. 1 - printed circuit board from Kelvin Part (number 850500) or fabricate one from supplied art work

F. Miscellaneous parts list for Strobe Counter

2. Equipment/Machines/Tools

A. Soldering iron (25 watt maximum)
B. 60/40 rosin core solder
C. Needle nose pliers

D. Wire cutter
E. VOM or DVM
F. Frequency counter
G. Electric motor, e.g., fan, drill, etc.
H. Oscilloscope

3. Handouts

A. Student component of TAM #18
B. Activity #1 - Construction guide for electronic thermometer
C. Activity #2 - Construction guide for electronic strobe counter

4. Instructional Resources

A. Catalogs (construction equipment & materials)
  1. Kelvin Electronics
     7 Fairchild Avenue
     Plainview, NY 11803
  2. Mouser Electronics
     National Circulation Center
     P.O. Box 699
     Mansfield, TX 76063

B. Books
  1. Encyclopedia of electronic circuits. Volume I by Rudolf F. Graf (Tab Books)
  2. Encyclopedia of electronic circuits. Volume II by Rudolf F. Graf (Tab Books)
  3. Linear Data books (e.g., National, Fairchild)

Management/Logistics:

1. Related TAMS

While this TAM is independent of others, it could possibly be used with TAM #17 - Applying Electric Motors.

2. Evaluation/Grading

A che[illegible]eet is provided in the post-test section of the instructor guide, which [illegible]signed for use in assessing student competencies related to material presented throughout the TAM. The quality of the finished project will also be an important indicator of how well students have grasped the information.

3. Suggested Schedule/Time

The time suggested for this TAM is one to two weeks.

4. Instructional Management

Be sure that students are properly informed about the hazards of scalding in Activity #1. It is also important that students are properly informed about the hazards of circular motion of fans or motors.

Key Instructional Suggestions:

1. **Safety**

   The major precautions that need to be taken here involve care in the use of boiling water and heating elements, the prevention of electric shock, and care in the handling of the temperature transducer.

2. **Motivation**

   Have a student turn the lights off and then turn the power on to the photo strobe. Vary the frequency of the strobe from the low to high frequency. Now have a student walk or move arms with the strobe flashing. This will provide the student with stop-action movement.

3. **Prerequisite Information**

   Students should have some knowledge of electricity/electronics, including how to construct and troubleshoot electronic circuits.

4. **Demonstrations**

   A. Use the temperature sensor to determine the temperature of the room.
   B. Use the strobe to measure the speed of a small motor.

5. **Reinforcement**

   This TAM will reinforce a number of important principles of electronics and physics. Specifically, it will reinforce previously-learned materials with series/parallel resistor networks, wheatstone bridge and stroboscope theory, as well as feedback principles which are important in a variety of disciplines (e.g., biology, ecology, aviation, etc.).

6. **Attitudes**

   This module provides an excellent means of addressing general safety attitudes, housekeeping and general cleanliness, as well as principles of good circuit construction techniques.

7. **Remediation/Enrichment**

   Remediation: Repeat the initial demonstration with the photo strobe. Pair up advanced students with those that are having trouble. A review could also be done on resistor color codes, Ohm's Law, and series/parallel resistor networks.

   Enrichment: Have students explore the many uses of electronic thermometers and photo strobes in industry.

8. **Summary & Review**

   In Activity #1 of this TAM, students have constructed an electronic thermometer. In Activity #2, they made a photo strobe. Students explored the uses of these items as electronic instrumentation. The experiences and skills acquired during these activities can be transferred to other areas of energy and power technology.

9. Review Questions & Answers

A. A ____________________ is an electronic device used to measure temperature. (*thermometer*)

B. The electronic thermometer is used to help determine if a device is operating at a(n) ___________________ temperature. (*normal*)

C. When soldering semiconductors, care should be taken to prevent the device from becoming too ___________. (*hot*)

D. The _______________________ can be used to determine the frequency of a rotating shaft. (*photo strobe*)

E. What is the main advantage for using the photo strobe over other means of determining the speed of a motor? (*It does not require a physical connection*)

Date: ________ **Class:** ________ **Name:** __________________________

TAM #18: Using Electronic Instrumentation - Pre-test

1. Static testing of a device requires
    - A. The device to be in operation
    - B. The device NOT to be in operation

2. Dynamic testing of a device requires
    - A. The device to be in operation
    - B. The device NOT to be in operation

3. The temperature at which water freezes:
    - A. Is directly related to its height above sea level
    - B. Is a universal constant

4. The temperature at which water boils:
    - A. Is directly related to its height above sea level
    - B. Is a universal constant

5. A stroboscope is used to:
    - A. Measure the speed of a rotational device
    - B. Used to measure electronic signals

Date: ________ **Class:** ________ **Name:** ____________________________

TAM #18: Using Electronic Instrumentation - Post-test

Directions: Evaluate the student by checking the appropriate letter to indicate the degree of competency.

Rating Scale:
^ **Mastered** - has performed task satisfactorily
0 **Not Mastered** - has not performed the task satisfactorily
v **No Exposure** - no experience or knowledge in this area.

^ 0 v Identify electrical Hazards.

^ 0 v Identify and practice shop safety.

^ 0 v Identify and practice safe soldering methods.

^ 0 v Demonstrate safe and proper use of hand tools.

^ 0 v Demonstrate safe and proper use of AC line equipment, i.e., Ground Fault Interrupter (GFI).

^ 0 v Identify the hazards of rotational devices.

^ 0 v Describe the operation of the electrical thermometer.

^ 0 v List applications for thermometers in industry.

^ 0 v Demonstrate proper soldering techniques in board construction.

^ 0 v Demonstrate proper construction techniques in circuit board construction, i.e., proper component handling.

^ 0 v Demonstrate proper breadboard techniques in circuit construction.

^ 0 v List procedure in calibrating the electronic thermometer.

^ 0 v Perform the calibration of the thermometer.

^ 0 v Describe the three temperature scales and the difference between them.

^ 0 v Describe the operation of a stroboscope.

^ 0 v List applications for the stroboscope in industry.

^ 0 v List procedure in using a stroboscope.

TAM #18- Test Keys

TAM #18 - Pre-test Answers

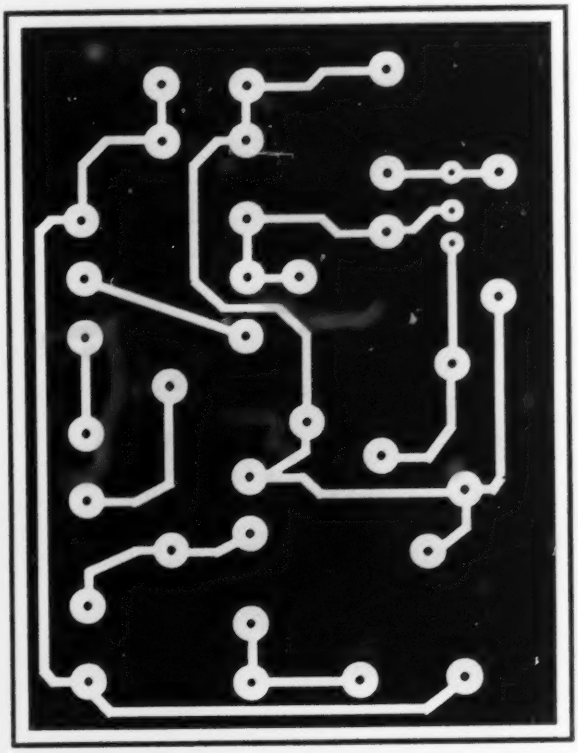
1. B 2.A 3. B 4 .A 5. A

TAM #18 - Post-test Answers

A check off form is used as a post-test.

TAM #18: Using Electronic Instrumentation

PC Board Artwork



TAM #18: Using Electronic Instrumentation

Student Component

Introduction:

This TAM deals with the use of electronic instrumentation. In the first activity, you will build an electronic thermometer. This device may be used for a variety of sensing operations. In particular, we will see how it may be used to predict how a motor is performing over a period of time. In the second activity, you will construct an electronic strobe. This device, when used with a frequency counter or oscilloscope, will allow you to measure the exact speed of a rotational device. These two devices are a small sampling of devices used by industry.

Competencies: Following the completion of this TAM, you will be able to:

1. Define basic electrical terminology as it pertains to instrumentation.
2. Demonstrate the safe use of equipment, supplies, materials, and processes that are related to instrumentation.
3. Exhibit positive work habits and attitudes as they relate to the safe and skillful operations of electric/electronic test equipment and tools.
4. Identify the hazards involved in connecting instrumentation to equipment.
5. Use electronic components to construct a series of simple test equipment.
6. Differentiate between static and dynamic testing of equipment.
7. Differentiate between direct and remote connections of test equipment.

Module Overview:

This module contains two construction activities, one for an electronic thermometer and another for an electronic strobe. In Activity #1, a student (or group of students) will construct an electronic thermometer. The student will learn how to calibrate and use this instrument. Activity #2 will involve the construction of an electronic counter consisting of a strobe light. The strobe will then be used in conjunction with a frequency counter or oscilloscope to measure the speed of a motor.

Activity Sequence:

1. Participate in the instructor's demonstration for this TAM. Follow all instruction, e.g., reading the assigned material and reviewing the procedural steps.
2. Complete the pre-test given by the instructor.
3. Do Activity #1 -- Constructing the electronic thermometer.
4. Do Activity #2 -- Constructing the electronic photo strobe.
5. Review the material and summarize in your own words.
6. Complete the post-assessment procedure.

Key Information:

1. **Class Presentations**
    - The distinction between static and dynamic testing
    - The importance of electronic instrumentation
    - The identification of some uses of electronic instrumentation

2. **Demonstrations**
    - Soldering techniques
    - Using an electronic thermometer
    - Using a photo strobe

3. **Safety - major concerns**
    - Electric hot plates
    - Proper hand tools usage
    - Electric shock
    - Handling hot items
    - Proper soldering techniques
    - Special attention must be paid when students work with any type of device that involves circular motion, such as a fan.
    - When constructing either of the activities, the student should practice safe and proper work habits, i.e., proper use of hand tools and soldering equipment.

4. **Personal Activity**

    As your homework, you should perform library research and read about the history of measurement and instrumentation. Alternatively, visit a local manufacturing plant or other industrial plant and discuss the damage that heat causes to electric motors. You can also discuss the needs for static as well as dynamic testing by maintenance crews.

Glossary:

1. **Absolute Zero** -- The theoretical lowest possible temperatur; where molecular motion ceases.
2. **Celsius** -- A unit of temperatur; a temperature scale where water freezes at zero degrees and boils at 100 degrees.
3. **DMM** -- Digital multimeter
4. **DVM** -- Digital volt meter
5. **Fahrenheit** -- A unit of temperature; a temperature scale where water freezes at 32 degrees and boils at 212 degrees.
6. **Frequency** -- The number of occurrences of a periodic phenomenon.
7. **Kelvin** -- A unit of temperature; uses the same scale as Celsius, but its zero point is at absolute zero.
8. **RPM** -- Revolutions per minute.
9. **Solder** -- An alloy primarily of tin and lead.
10. **Stroboscopic** -- An intensified spotlight that flashes at a given rate so that motion coincides with the frequency of the flash.
11. **Thermometer** -- An instrument for measuring temperature using mercury, electrical, or electronic means.
12. **VOM** -- Volt-ohm meter

Needed Materials:

1. **Supplies Required**
    - A. Parts list for a Fahrenheit Thermometer
        1. 1 - 33K Ohm 1/4 watt resistor
        2. 1 - 82K Ohm 1/4 watt resistor
        3. 1 - 56K Ohm 1/4 watt resistor
        4. 1 - 49K Ohm 1/4 watt resistor
        5. 1 - 220K Ohm 1/4 watt resistor
    - B. Parts list for a Celsius Thermometer
        1. 1 - 33K Ohm 1/4 watt resistor
        2. 2 - 120K Ohm 1/4 watt resistor
        3. 1 - 68K Ohm 1/4 watt resistor
        4. 1 - 220K Ohm 1/4 watt resistor
    - C. Parts list common for both
        1. 1 - 1K 10-turn potentiometer
        2. 1 - 10K 10-turn potentiometer
        3. 1 - 0.01 uF capacitor
        4. 1 - 1N4148 signal diode or equivalent
        5. 1 - LM317 adjustable regulator
        6. 1 - 1 uF electrolytic or tantalum capacitor 15WVDC
        7. 1 - 0.1 uF capacitor
        8. 1 - 240 Ohm 1/4 watt resistor
        9. 1 - 5K 10-turn potentiometer
        10. 72 inches - 20-24 gauge stranded wire or 36 inches of Belden 9239 Low noise coaxial cable or equivalent
    - D. Miscellaneous parts list for thermometers
        1. Crushed ice or ice cubes
        2. Glass thermometer (or equivalent)
        3. Styrofoam cups
        4. Container to hold boiling water
        5. Hot plate or other device capable of producing enough heat to boil water
    - E. Parts list for Strobe Counter

        (NOTE: The following components are available from Kelvin Electronics. The following parts are included in Kelvin part number 840208)

        1. 1 - 1K Ohm 1/2 watt resistor
        2. 2 - 22 MFD capacitor 450WVDC
        3. 2 - IN4004 diodes
        4. 1 - 1Meg Ohm 1/4 watt resistor
        5. 1 - 500K potentiometer panel mount
        6. 1 - 0.47 uF capacitor 250WVDC
        7. 1 - SCR
        8. 1 - Trigger transformer
        9. 1 - Xenon strobe flash neon bulb
        10. 1 - push button switch
        11. 1 - power cord
        12. 24 inches of solid wire

        13. 1 - printed circuit board from Kelvin Part (number 850500) or fabricate one from supplied art work

    F. Miscellaneous parts list for Strobe Counter

2. Equipment/Machines/Tools

    A. Soldering iron (25 watt maximum)
    B. 60/40 rosin.core solder
    C. Needle nose pliers
    D. Wire cutter
    E. VOM or DVM
    F. Frequency counter
    G. Electric motor, e.g., fan, drill, etc.
    H. Oscilloscope

3. Handouts/Instructional Resources

    A. Activity #1 - Construction guide for the electronic thermometer
    B. Activity #2 - Construction guide for the electronic strobe counter

Activity #1: Constructing the Electronic Thermometer - Plan of Procedure

1. Construct the following circuit on either breadboard or a printed circuit board. For the printed circuit board, see Handout #1. Note that schematics are provided for both the Celsius (Figure #1) and Fahrenheit (Figure #2) thermometers. Select one.

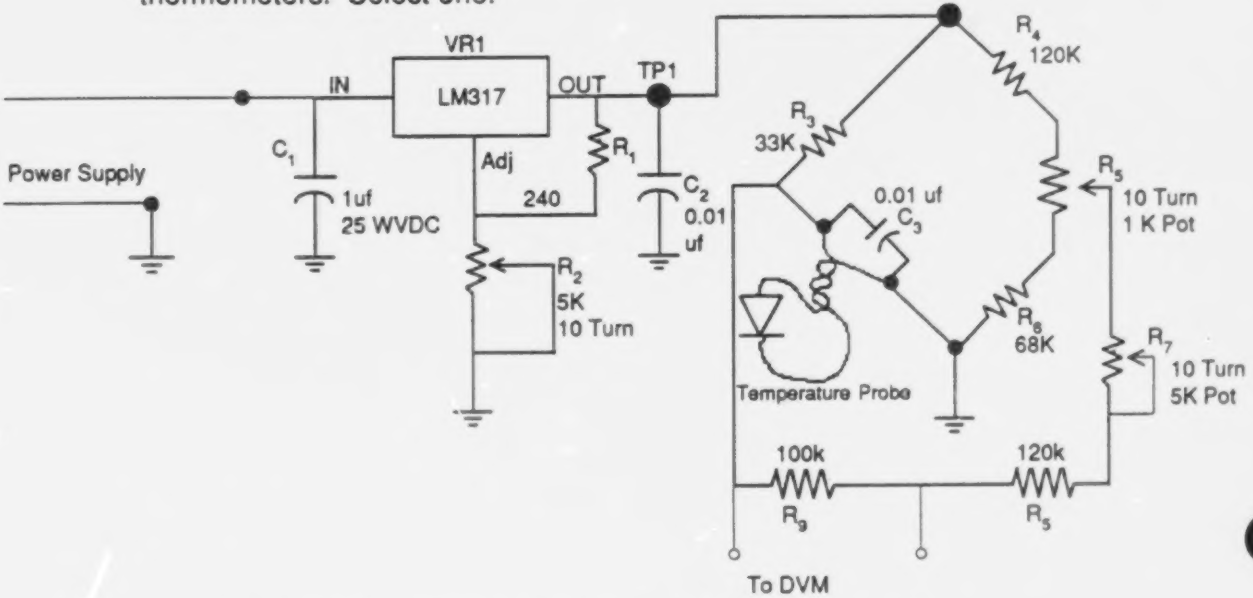

VR1
LM317
IN
OUT
TP1
Adj
Power Supply
C_1
1uf
25 WVDC
R_1
240
C_2
0.01
uf
R_2
5K
10 Turn
R_3
33K
R_4
120K
0.01 uf
C_3
R_5
10 Turn
1 K Pot
R_6
68K
R_7
10 Turn
5K Pot
Temperature Probe
100k
R_9
120k
R_5
To DVM

Figure #1 - Celsius Thermometer Circuit Schematic

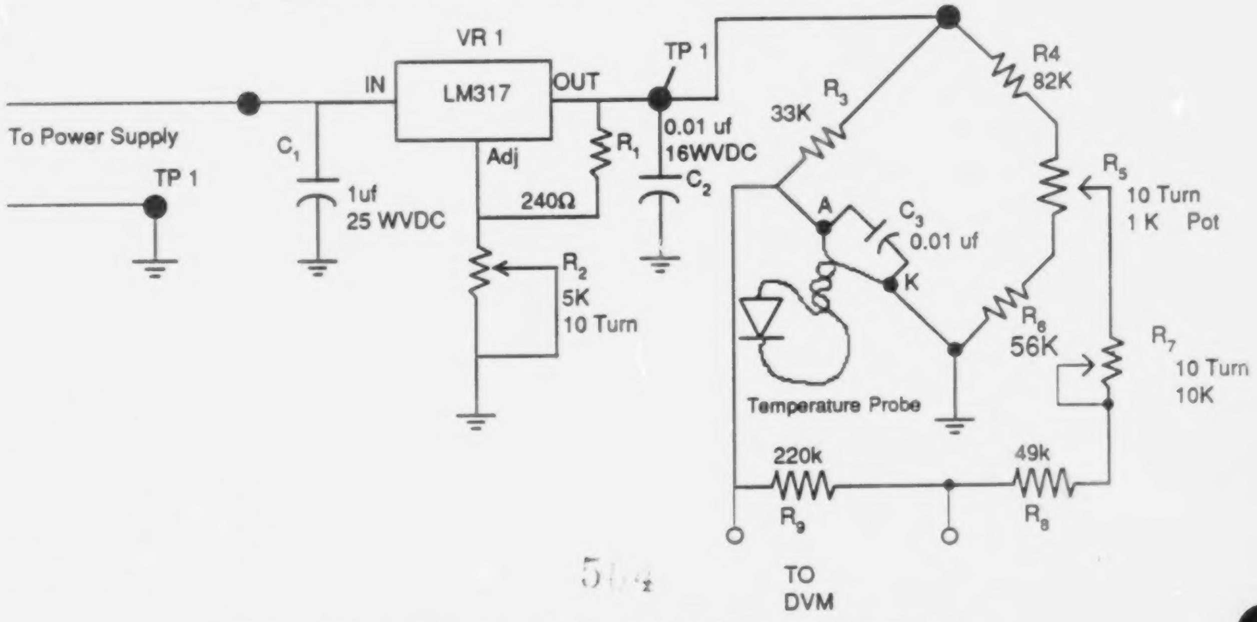

VR 1
LM317
IN
OUT
TP 1
Adj
To Power Supply
TP 1
C_1
1uf
25 WVDC
R_1
240Ω
0.01 uf
16WVDC
C_2
R_2
5K
10 Turn
33K
R_3
R4
82K
A
C_3
0.01 uf
K
R_5
10 Turn
1 K Pot
R_6
56K
R_7
10 Turn
10K
Temperature Probe
220k
R_9
49k
R_8
TO
DVM

Figure #2 - Fahrenheit Thermometer Circuit Schematic

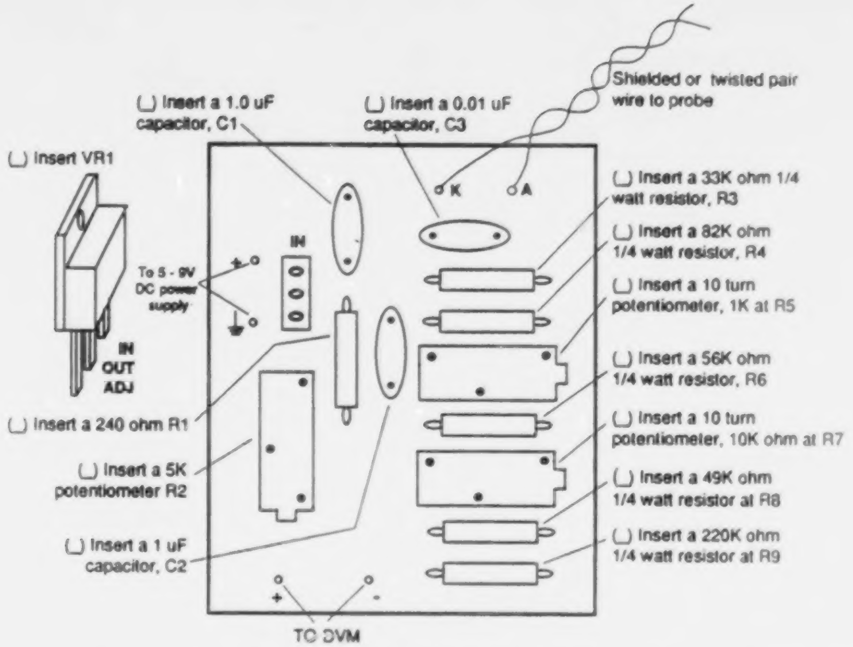

☐ Insert VR1
IN
OUT
ADJ
☐ Insert a 1.0 uF capacitor, C1
☐ Insert a 0.01 uF capacitor, C3
Shielded or twisted pair wire to probe
K
A
IN
To 5 - 9V DC power supply
+
☐ Insert a 33K ohm 1/4 watt resistor, R3
☐ Insert a 82K ohm 1/4 watt resistor, R4
☐ Insert a 10 turn potentiometer, 1K at R5
☐ Insert a 56K ohm 1/4 watt resistor, R6
☐ Insert a 10 turn potentiometer, 10K ohm at R7
☐ Insert a 49K ohm 1/4 watt resistor at R8
☐ Insert a 220K ohm 1/4 watt resistor at R9
☐ Insert a 240 ohm R1
☐ Insert a 5K potentiometer R2
☐ Insert a 1 uF capacitor, C2
+
-
TO DVM

Figure #3 - Thermometer Parts Placement Diagram

2. Construct the temperature probe as shown below (Figure #4).

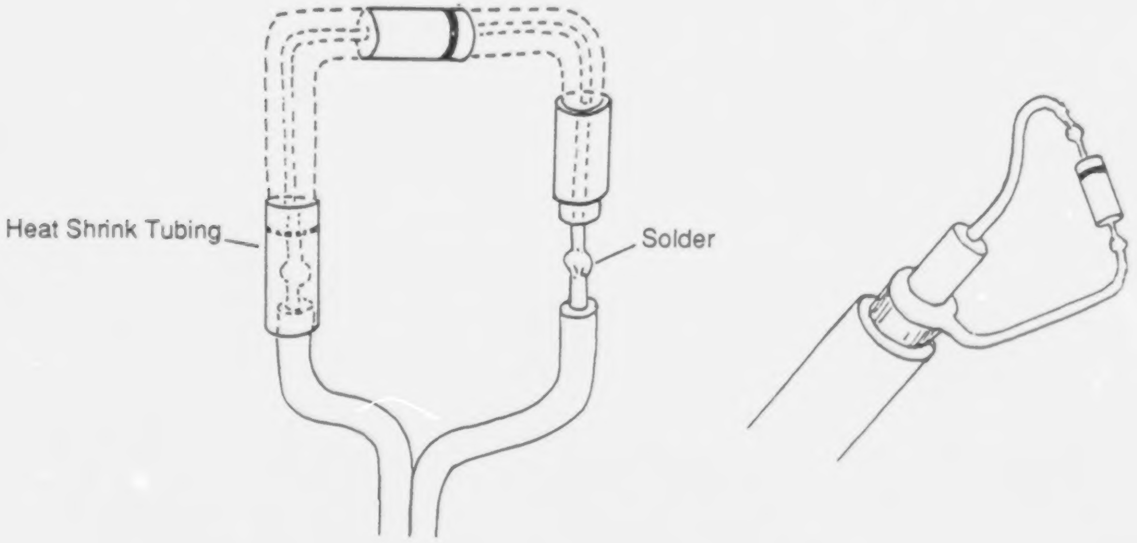

Heat Shrink Tubing
Solder

Figure #4 - Temperature Probe

3. To calibrate the thermometer, you will need a regular thermometer, a container of crushed ice and a container of boiling water (The calibration procedure is listed below).
   A. Adjust the 1K Ohm and the 10K Ohm potentiometers to mid-range. R5 balances the bridge to indicate the freezing point of water (32°F or 0°C).

R5 is the scaling resistor which will reduce the voltage to the correct scale and is also used to set the high temperature point.

B. Connect a DC (direct current) power supply (could be a 6-9 volt DC battery) to the device NOTE: Please observe the correct polarity).

C. Connect the plus (+) lead of the DVM to the OUT (center pin) of the LM317 regulator.

D. Connect the minus (-) lead of the DVM to the GROUND of the power supply.

E. Set the Digital Volt Meter to read 0 - 2 Volt scale.

F. Adjust variable resistor R1 so the Voltmeter reads 1.350 Volts DC (or as close as possible).

G. Now move the board's wire labeled plus (+) (probe +) to the plus (+) of the Digital Volt Meter.

H. Now move the board's negative (-) (probe -) to the negative (-) of the DVM.

I. Immerse the glass thermometer the ice bath.

J. Immerse the diode probe the container of ice and water. It is critical for the container to hold an equal amount of crushed ice and water so the temperature will be as close to 32°F (0°C) as possible. Let the probe set for a couple of minutes so it will have time to stabilize to the water temperature.

K. Set the Digital Volt Meter to read 0 - 200 millivolt scale.

L. Adjust R5 to produce the desired reading of 32.0°F (0.00°C).

M. Set the Digital Volt Meter to read 0 - 2 Volt scale.

N. Immerse the diode probe the boiling water. Allow time for the probe to equalize to the new temperature.

O. Adjust variable resistor R7 for an indication of boiling water (212.0° or 100.0°) at sea level.

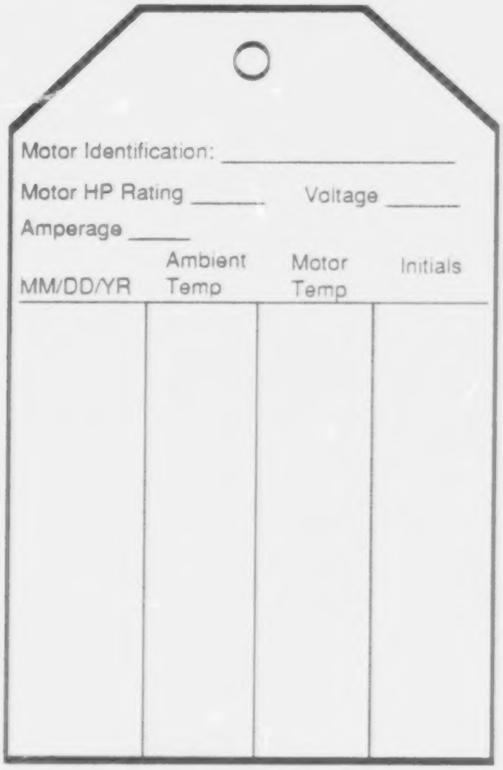
P. You may wish to repeat steps I to N to increase the accuracy of the thermometer.

(**NOTE**: If R3 is at one end of its rotation, you may add a 1 Meg Ohm resistor parallel to either R4 or R6. If R7 is at the end of rotation you may add a 1 Meg Ohm resistor across R8 or R9)

Discussion: Motors convert electrical energy into mechanical energy by harnessing the power of magnetism. A 100 percent efficient motor will convert all of the electrical energy to mechanical energy. Since this type of efficiency is not possible in our world, the motor must consume some of the input energy. This energy is lost to heat. Some of the heat is generated by the resistance of the wire, some by the flux field, some by other areas, but the majority is caused by friction. This lost energy, which is converted into heat, plays a major part in the operation of the motor and its ultimate lifespan. By reviewing the specifications for the motor in the NEMA manual, you should be able to determine its performance. If the motor varies significantly (greater than 10 percent), then a more thorough check is in order.

One way to monitor the performance of motors is by recording how much current the motor uses under normal operating condition over a period of time. To perform this task, you would need to use a clamp-on amp meter. With a single phase motor you would locate the load wire either at the contactor (heavy-duty relay) or at the motor itself. This task can be somewhat tedious. In addition, it can expose the service person to a high voltage risk. Other problems may also arise for example, sometimes the contactor box is located at a central electric panel away from the motor. Also, the contactor could control several motors.

Another method employed by industrial maintenance personnel involves measuring the temperature of the motor. This temperature is related to the ambient (surrounding) air temperature, the motor rating, and the load. This temperature will vary from motor to motor and among brands. You can monitor the performance of a motor by measuring its temperature as well as its amperage. If you do this over a period of time, you will be able to determine when the motor starts to fall off its performance rating. By creating a table with dates, motor temperature and ambient temperature, you can monitor the performance of a motor. A sample table is given below (Figure #5).



Motor Identification: ____________________

Motor HP Rating ______ Voltage ______

Amperage _____

MM/DD/YR	Ambient Temp	Motor Temp	Initials

Figure #5 - Motor Performance Data Table

Activity #2: Constructing the Electronic Photo Strobe - Plan of Procedure

1. Construct the following circuit on either breadboard or a printed circuit board (Figure #6). For the printed circuit board, see the accompanying handout.

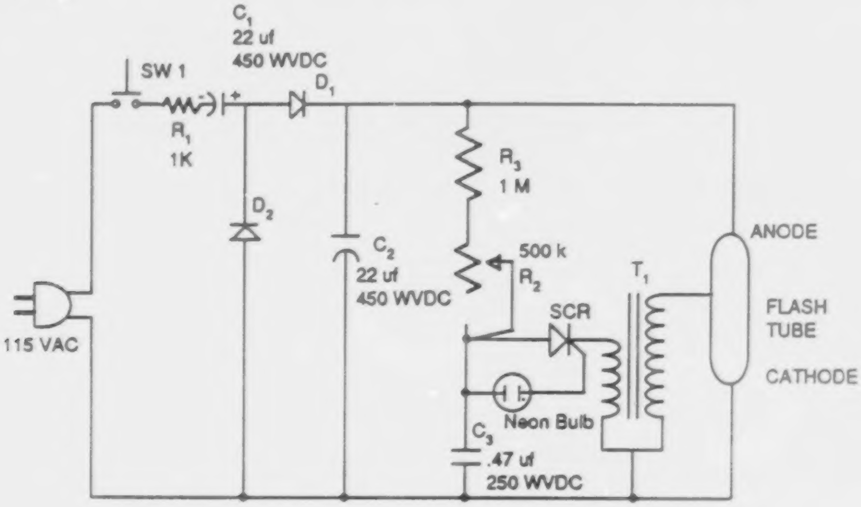
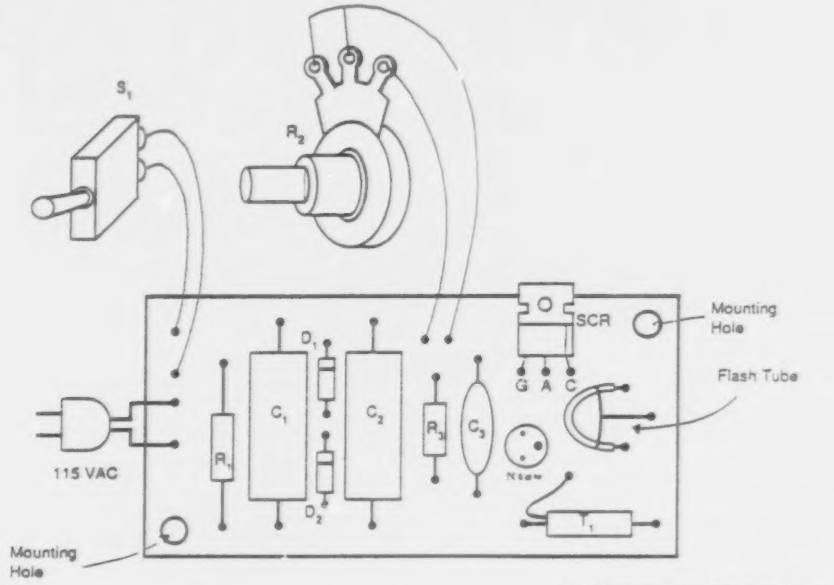

C_1
22 uf
450 WVDC
SW 1
D_1
R_1
1K
D_2
R_3
1 M
ANODE
C_2
22 uf
450 WVDC
500 k
R_2
T_1
SCR
FLASH
TUBE
115 VAC
CATHODE
Neon Bulb
C_3
.47 uf
250 WVDC

Figure #6 - Electronic Strobe Schematic

2. Construct the photo strobe as shown below (Figure #7).


S_1
R_2
SCR
Mounting Hole
D_1
G A C
Flash Tube
C_1
C_2
115 VAC
R_1
R_3
C_3
Neon
D_2
T_1
Mounting Hole

Parts Placement for Electronic Strobe

Figure #7 - Electronic Strobe Parts Placement Diagram

3. Industry uses many devices to measure the output speed of motors and gearboxes. One such analog device is the tachometer generator, which requires a physical connection to the motor in order to generate the resultant feedback voltage to display the speed. An example of this can be found in certain automobile speedometers.

   Another device which uses digital technology requires some sort of switching to occur for each revolution of the motor. This sensor could be a magnet attached to the shaft which opens and closes a reed switch, or it could induce a current into a coil. The net result is a pulse which can be fed to a digital counter set up to give RPM's.

   There are several disadvantages to either of these methods. Both methods require direct physical connection to the device. Another disadvantage is that the tachometer is usually a permanent fixture. This becomes costly when a motor's speed is checked on a quarterly basis. Activity #2 provides an alternative that overcomes these disadvantages. It involves using an alternative method to determine the speed of a motor or power train by using a stroboscopic device.

   This device produces a light that flashes at a frequency which can be adjusted to coincide with any repeating motion. When the rate of flash coincides with the motion, the motion appears to have stopped. At this point the frequency may be read from the dial. Since these devices are rather expensive to purchase, we have included a hobby version that is readily available to users. By using a strobe light and connecting a frequency counter (or oscilloscope), the student will be able to determine the speed of a simple motor.

   (NOTE: In the following procedure EXTREME care should be taken to prevent ELECTRICAL SHOCK. Please observe all safety rules regarding the handling of electrical devices.)

   A. Connect the plus (+) lead of the frequency counter (or oscilloscope) to the point labeled TP1 (test point 1).
   B. Connect the minus (-) lead of the frequency counter (or oscilloscope) to the point labeled TP2 (test point 2).
   C. Using a piece of masking tape, mark a single line on the shaft of the motor (if you are using a drill, mark a spot on the chuck).
   D. Now turn the motor on.
   E. Turn on the strobe light.
   F. Adjust the strobe light until the mark appears to be motionless. You will need to check both sides of the motor shaft to determine that you indeed see one motionless mark. If two motionless marks appear, you have the strobe at a harmonic frequency of the rotation. You will need to adjust the strobe rate until there is one.
   G. Note the frequency counter's display.

4. You may now adjust the speed of the motor, then repeat step F and record the new frequency.

TAM #18 - Summary

With the ever-increasing cost of manufacturing, industry has come to depend on greater sophistication of electronic instrumentation. The technology of electronic instrumentation has been rapidly increasing, with a strong emphasis on computerization and Programmed Logic Controllers (PLC). The need for competent and self-motivated personnel will be increasingly in demand.

Course: Introduction to Energy & Power Technology

Technology Activity Module #19

Getting The Job/Scholarship You Want

by: Yusuf Al-Hassan

TAM #19: Getting the Job/Scholarship You Want

Instructor Component

Activity Objective: The purpose of this activity is to help introduce students to the issues and procedures involved in preparing for a job or scholarship in areas related to energy and power technology. The student will be supported and guided through the strategies incorporated into MOView, Dictionary of Occupational Titles (D.O.T.), Occupational Outlook Handbook (O.O.H.), or similar guidance systems.

Activity Competencies: By completing this TAM, the student will be able to:

1. Demonstrate skills in job/scholarship identification, seeking, and application.
2. Identify and demonstrate desirable personal characteristics appropriate to employability, such as positive interpersonal skills, dependability, work attitude, communication ability, and personal hygiene/grooming.
3. Identify and discuss the potential for entrepreneurial activity in energy and power technology.
4. Demonstrate informed and meaningful occupational and educational choices.
5. Project a positive self-image, resourcefulness, thoroughness, and positive attitudes regarding work, future options, and life long learning.
6. Explore career/educational possibilities in a variety of technological areas including engineering, utility service work, and much more.

Module Instructions

Introduction:

This TAM is designed to provide guidance for students in the process of pursuing a job or scholarship in energy and power related areas. It is also designed to help them familiarize themselves with specific job-seeking skills, such as writing a resume, filling out a job application, and proper conduct during the interview.

Safety Considerations:

There are no special precautions for this TAM except that students will need to obtain permission from their parents/guardian for participation in the field trip.

Needed Materials:

1. **Supplies Required**
   - A. MO View
   - B. Dictionary of Occupational Titles and/or Occupational Outlook Handbook.

2. Equipment/Machines/Tools

A. Fiche viewer
B. IBM PC -(MOView is available on computer diskette)

3. Handouts

A. Student component of TAM #19
B. Handout #1 - Occupational Cluster Description Handout
C. Handout #2 - Career Deck Components
D. Handout #3 - Some Hints for Successful Interviewing & Job Searching

4. Instructional Resources

A. Books

1. __________. (1976). Job placement manual. Jefferson City, MO.
2. __________. (1976). Teaching techniques in developing job skills: Instructor's handbook. Jefferson City, MO.
3. __________. (1980). Help yourself to successful employment: Instructor's handbook (pp. 1-100). Jefferson City, MO.
4. Cabaup, B.M. (1989). Activities for the occupational outlook handbook (pp. 1-30). Bloomington, IL: Meridian Education Corporation. ISBN 0-936007-24-9
5. Career Planning and Placement Center. (1986). CPPC information series #73. Columbia, MO: University of Missouri-Columbia.
6. Gibson, R.R. (1976). Preparing for employment : Student handbook. Jefferson City, MO.
7. Goble, D.Y. (1985). How to get a job and keep it (pp. 1-67). Austin, TX: Steck-Vaughn Company. ISBN 0-8224-1574-0
8. Holland, L.J. (1985). The occupations finder. Odessa, FL: Psychological Assessment Resources.
9. Kushner, J.A. (1982). How to find and apply for a job. West Chicago, IL: Southwestern Publishing Co. ISBN 0-538-11070-8
10. Noland, G.L. (1980). Help yourself to successful employment: Student's handbook (pp. 1-88). Jefferson City, MO.
11. Rudolph, E.E., Johnson, B.R., & Jones, D.G. (1987). How to find & get the job you want. Bowling Green, KY. Johnson/Rudolph Educational Resources.
12. U.S. Dept. of Labor. (1986). Dictionary of occupational titles. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor.
13. U.S. Dept. of Labor. (1989). Occupational outlook handbook. Washington, DC: Bureau of Labor Statistics, U.S. Department of Labor.

B. Film slides/film/video

MO View

Management/Logistics:

1. Related TAMS

For additional information, refer to TAM #14 in the Materials and Processing Guide.

2. **Evaluation/Grading**

   Refer to the pre- and post-test section of the instructor component. Evaluation of material presented in this TAM can also be done through role-playing and/or video taping.

3. **Suggested Schedule/Time**

   The time suggested for this TAM is approximately 1 week.

Key Instructional Suggestions:

1. **Safety**

   There are no special safety precautions for this TAM.

2. **Motivation**

   Students often do not have an idea of their many options, capabilities, and potential. One of the real services you can do for them is to expand their awareness. You may do this through the material you present in class. Another way of accomplishing the same objective is to invite speakers from various occupational backgrounds to share their experiences with the class. Encourage the speakers to discuss what their self-perceptions were when they were the ages of your students. Also, they could talk about the path they followed to get to where they are today.

3. **Prerequisite Information**

   None.

4. **Demonstrations**

   Arrange for the school's guidance counselor to demonstrate/illustrate MO View, D.O.T. and O.O.H..

5. **Reinforcement**

   This TAM provides an opportunity to reinforce skills learned in English composition, public speaking, and psychology courses. For example, writing resumes and scholarships applications requires good composition skills. Other skills, such as public speaking, are reinforced through role-playing or through video taping simulated job or scholarship interviews. Some insights and social skills learned in psychology courses may help you secure a job or scholarship.

6. **Attitudes**

   Job search skills are some of the most important survival skills for individuals in our culture. Given the rapid pace of technological change, it is very likely that students will be engaged in the job interview process repeatedly throughout their lives.

7. **Remediation/Enrichment**

   Remediation: If time allows, it may be useful to view video taped interviews with students and offer constructive ways of improving performance.

   Enrichment: Students could interview persons who have recently completed the job search process and ask them for helpful advice.

8. Summary & Review

This TAM is designed to provide some practical, simulated experience with job or scholarship interviewing. Specific resource materials have been suggested. Several specific points are made. First, the job search process simply goes better if individuals know certain procedures and processes. Second, attitudes such as self-confidence, good work habits, the ability to work and relate well with peers, etc., are critical to both finding and keeping a job.

9. Review Questions & Answers

A. How does one get a job?

1. *Establishing career goals (short-or long-term)*
2. *Doing one's homework (learning about the job)*
3. *Preparing a quality resume*
4. *Completeing a job application form*
5. *Getting ready for an interview*
6. *Learning how to market job skills and abilities*

B. What are the essential components of a resume?

1. *Interest and abilities*
2. *Special skills and/or hobbies*
3. *Educational background*
4. *Work experience*
5. *Occupational goals*

C. How does one properly fill out an application form?

1. *If possible, arrange for the form to be typed.*
2. *Read the directions on the form carefully.*
3. *Fill out all the blanks carefully. If you have questions, contact someone in the personnel office.*
4. *Ask another person to review your information. It is always good practice to have others review your writing for grammar and punctuation.*
5. *If you will be completing an application at the business, take a listing of correct dates of previous employment and other pertinent information along with you for reference.*
6. *Include a resume with your application; remember, it may present information about yourself that the application form does not ask for.*

Date: ________ **Class:** ________ **Name:** ______________________________

TAM #19 - Getting the Job/Scholarship You Want - Pre-test

Instructions: True or **False:** Place **T** for **true** statements or **F** for **false** statements in the space provided.

1. ____ When going for a job interview, you should always be neat and clean even if the potential job does not require dressing up.

2. ____ If you are sick and cannot meet your appointment, it is all right to tell them the following day.

3. ____ It is better for you to appear tense and nervous so they know you really need the job.

4. ____ The interviewer will look for several personal characteristics, such as ability, enthusiasm, etc.

5. ____ A good person can get a job, even at a time when there are more people than there are jobs, provided he/she learns the knack of getting a job.

6. ____ The first step in your job search process is writing a resume.

7. ____ Humility is generally preferable to cockiness.

8. ____ Some job ads generally list a box number as the only address and normally ask for an application letter instead of a personal interview.

Date: ________ **Class:** ________ **Name:** ______________________________

TAM #19 - Getting the Job/Scholarship You Want - Post-test

Instructions: Circle the letter next to the phrase that correctly completes the sentence.

1. When going for an interview you should:
   - A. Be neat and clean
   - B. Get a good night's sleep
   - C. Use correct grammar
   - D. All of the above

2. The interviewer will attempt to discover:
   - A. Your ability to think on your feet
   - B. How much debt you have
   - C. Information about your personal affairs
   - D. What your religious persuasion is

3. The important thing about the interview is to:
   - A. Be prompt or somewhat early
   - B. Visit casually with the secretary
   - C. Be careful not to take too much of the employer's time
   - D. Both A and B

4. Statements to avoid when being interviewed are:
   - A. I need the money
   - B. I will take any job you have
   - C. I really need a job
   - D. All of the above

5. A resume is:
   - A. A record of your past work and educational experience
   - B. An indication of your interests and abilities
   - C. One way that you have of sharing information about yourself
   - D. All of the above

6. The first thing you should do in the process of determining what work you are best qualified to do:
   - A. Prepare a resume
   - B. Take a complete inventory of yourself
   - C. Prepare for interview
   - D. Fill out application form

7. When you have a chance to apply for a job for which you are only marginally qualified, the best approach is to:
   - A. Not apply for the job
   - B. Be open about the qualifications that you have and do not have
   - C. Build the best case you can even if it stretches the truth somewhat. You have to get into the door to be able to prove yourself

TAM #19 - Getting the Job/Scholarship You Want - Test Keys

TAM #19 - Pre-test Answers

1. T
2. F
3. F
4. T
5. T
6. F
7. T
8. T

TAM #19 - Post-test Answers

1. D
2. A
3. D
4. D
5. D
6. B
7. B

TAM #19: Getting the Job/Scholarship You Want

Student Component

Introduction:

Chances are pretty good that your grandparents worked at the same job for most of their lives. Someone went into a certain occupation and that was pretty much it. Those days are gone. Technology is changing like crazy. Knowledge is growing fast. Now you could ask..."What JOBS am I going to do in my life?" , or "I wonder how many jobs I'll have that don't even exist yet today?". Much of your future depends on how well you can continue to learn. Another big part of it is being able to sell an employer on what you know. That's what this TAM is all about.

Competencies: Following the completion of this TAM, you will be able to:

1. Demonstrate skills in job/scholarship identification, seeking, and application.
2. Identify and demonstrate desirable personal characteristics appropriate to employability such as positive interpersonal skills, dependability, work attitude, communication ability, and personal hygiene/grooming.
3. Identify and discuss the potential for entrepreneurial activity in energy and power technology.
4. Demonstrate informed and meaningful occupational and educational choices.
5. Project a positive self-image, resourcefulness, thoroughness, and positive attitudes regarding work, future options, and life long learning.
6. Explore career/educational possibilities in a variety of technological areas including engineering, utility service work, and much more.

Module Overview:

With the way jobs are today, it's really important that you offer an employer more than skills and knowledge. That's only part of the ticket. You've got to develop the ability to sell yourself and your skills to the employer. In our culture you'll probably get lots of experience. The average person now has five different careers during a working lifetime. So you'll probably have lots of experience at interviewing for jobs. That's what this TAM is designed to help you do.

Most of the TAMs in this guide deal directly with energy and power technology. This TAM does that and more. There are all kinds of job opportunities in Energy & Power related occupational areas. Think of working with computers, satellites, space transportation and exploration, superconductivity, and lasers. Consider working in a power plant or developing alternative energy conversion devices. The possibilities are endless.

Skills that will help you in Energy & Power technology will also serve you well in other areas of technology. You're the generation that's going to lead the world into the year 2000. Give it a shot. Prepare for it today!

Key Information:

1. **Class Presentations**
   - Using MO View
   - Using D.O.T./O.O.H.

2. **Demonstrations**
   - How to use MO View
   - Walking through techniques in developing job-seeking skills
   - The interviewing process

3. **Safety**
   - You will need to obtain permission from parent/guardian for the field trip

4. **Personal Activity**

   Several different kinds of activities can be found in this TAM. You'll have the chance to practice developing a resume. Do a good job with this and, who knows, it just might land you your first job! You will also be introduced to some procedures and resources that will help you start thinking about the directions that you would like your career to follow or in which to further education.

Glossary:

1. **Applicant** -- A person who applies for something such as a job, etc.
2. **Application** -- A request made personally or in writing.
3. **Appointment** -- An agreement to meet at a fixed time.
4. **Career** -- The totality of work one does in his/her lifetime.
5. **D.O.T.** -- Dictionary of Occupational Titles. A career guidance resource which lists various occupation as they correspond to work personalities.
6. **Employment** -- Being hired to gain entrance into the world of work.
7. **Hiring Process** -- Procedure of selecting applicants for jobs.
8. **Job Cluster** -- A group of jobs with different titles that require some of the same competencies and characteristics.
9. **Job Opening** -- An opportunity for work.
10. **Job Title** -- A name given to a particular position or work.
11. **O.O.H.** -- Occupational Outlook Handbook. A career guidance resource which provides brief descriptions of various occupations by industry designation, alphabetical listings, and other means.
12. **Preparation** -- The career development stage during which individuals begin to act on tentative career plans by choosing subjects or experiences that develop competencies required for the desired job.
13. **Profession** -- An occupation that requires special education, usually a college degree.
14. **Resume** -- A brief description of the applicant's personal data, experiences and general qualifications which allow employers to determine if an interview or candidate is appropriate.
15. **Skills** -- Abilities gained through knowledge, practice and training.
16. **Work** -- An activity that produces something of value for other people.

Needed Materials:

1. **Supplies Required**
    - A. MO View
    - B. Dictionary of Occupational Titles and/or Occupations Outlook Handbook

2. **Equipment/Machines/Tools**
    - A. Fiche Viewer
    - B. IBM PC (MO View is available on computer diskette)

3. **Handouts**
    - A. Student Component of TAM #19
    - B. Handout #1 - Occupational Cluster Description Handout
    - C. Handout #2 - Career Deck Components
    - D. Handout #3 - Some Hints for Successful Interviewing & Job Searching

TAM #19: Getting the Job/Scholarship you Want

Activity #1: How to Prepare a Resume - Plan of Procedure

1. One of the first steps in preparing a resume is deciding on a style. While there are a number of acceptable styles, you would do well to follow the steps outlined in this activity.

2. Ask people you know if you may look at a copy of their resume. You can ask teachers in the school, parents, or adults that you know who are in positions to hire people.

3. Look the resume over. What do you like? What looks good? What kinds of things does it say that you would like to say about yourself?

4. Ask the same persons that you obtained the samples from to respond to the above questions. What appeals to them in a resume? How long do they like for them to be? Is there anything that should be removed from your resume? What about the format and the way it looks?

5. After getting this background information, decide what kind of format and information you want to use for yourself.

6. The next major step is to decide exactly what you want to say about yourself.

7. Make short lists which contain the items in the following steps:

   A. A statement of your occupational goals. This will assist you as you try to clarify what future job possibilities appeal to you.
   B. List your educational background. Include any particular emphasis area(s).
   C. List your previous work experience. Part-time or short-term jobs may also be included.
   D. Include a section on extracurricular activities such as sports, hobbies, volunteer experiences, honors and awards, leadership roles, campus activities, etc. These help to give the employer a more complete picture of yourself and your potential.
   E. References. Some employers prefer that these be listed on the resume. Others will request references from you directly. It is best to present a range of persons such as teachers, former employers, friends, etc. Many employers prefer some variety. It is best to avoid the excessive referencing of relatives, close friends, or clergy.

8. Wordprocess your information into the format that you have chosen.

9. At this point, share the rough draft with another person. Have him or her review it for thoroughness, format, spelling, omissions, abbreviations (which should be avoided), etc.

10. Edit the material using a word processor or typewriter, as appropriate.

RESUME
Charles Berkley
CAREER GOAL

11. If using a word processor, experiment with a variety of different fonts, sizes and layouts until you have a pleasing resume.

TAM #19: Getting the Job/Scholarship You Want

Activity #2: How to Find the Job You Want - Plan of Procedure

1. Research jobs utilizing MO View or D.O.T./O.O.H.

LIBRARY
DICTIONARY OF OCCUPATIONAL TITLES
DOT
OCCUPATIONAL
U.S. GOVERNMENT

2. Characterize two jobs in energy and power according to educational requirements, demands, salary and other aspects.
3. Make a list of sources of job announcements. This can include bulletin boards in grocery stores or at actual job sites, newspaper want ads, word of mouth, employment agencies, the yellow pages, etc.
4. Based on your research, select 3-4 job possibilities.
5. From this listing, identify persons who are working in those occupations and would be willing to have you visit with them about their job.
6. As a total class activity (or working in small groups), brainstorm to formulate a list of questions that you would like to ask the employer in an interview.
7. Do a video-taped role-play simulation of an interview situation.
8. View the tape and note both your strong and weak points.
9. Conduct a job interview with an actual employer. This need not be for a job you actually plan to take. It is possible to obtain an employer's permission to have you do this as a school activity for the interviewing experience.
10. Pose the questions the class developed to the employer.
11. After the interview, ask the employer to evaluate your resume and the way you presented yourself in the interview situation.
12. Debrief the experience with the class. How did it go? What did the group learn about the interviewing process in general? Were there enough questions asked? Were they the right kinds of questions? Did the employer ask the kinds of questions that you expected him or her to ask?

TAM #19: Getting the Job/Scholarship you Want

Activity #3: How to Apply For a Job - Plan of Procedure

1. The initial letter. One of the best ways to get more information about a job is through letter writing. This is a way of selling yourself by writing a neat and informative letter. This letter may lead to an interview and perhaps a job in which you are interested. Your letter should tell employers what type of person you are, the kind of job you are interested in, what you have to offer to the company and that you are interested in an interview. There are three types of letters:
   A. Application letter, which is written when you are aware a job opening exists and you are applying for it.
   B. Letter of inquiry, which is written when you are seeking information for an employer about a possible job opening. Also, it is used for requesting an interview, but you have no basic idea whether there is an opening or not.
   C. Cover letter, which answers an ad and is written when you are sending your resume in response to an advertisement for a particular job.

2. The format:
   A. First paragraph should introduce yourself to the employer and state your purpose for writing the letter.
   B. Second paragraph should consist of specific statements about the employment you want. It should include brief information about your knowledge of the company.
   C. Third paragraph should contain your qualifications and experience.
   D. Fourth and last paragraph should be clear as to what you desire, such as additional information or an interview and/or that you will follow up with a telephone call in a few days.

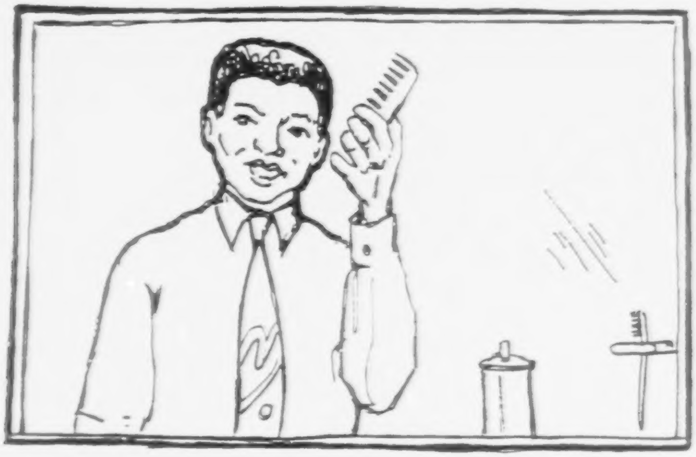
-- Adopted from Johnson/Rudolph, 1988

3. Writing an application letter:
   A. Write only on one side of white paper.
   B. Write neatly and clearly, using typewriter or pen.
   C. Complete all sentences and spell words correctly.
   D. The letter should be short and precise.
   E. Explain why you want the job.
   F. Write briefly about your educational qualifications and work experience.
   G. Request an interview.
   H. Make sure your letter attracts the attention of the employer.

-- Adopted from Goble, 1985

4. Completing an Employment Application.
   A. Obtain an employment application form from an employer. Make arrangements to do this as a school project. See if they would be willing to review your completed applications from the viewpoint of an actual employer.
   B. Carefully follow all instructions.
   C. Write clearly (if possible, arrange to type the application).
   D. Be accurate in filling out the form. If you have questions, seek clarification rather than guessing or risking giving incorrect information.
   E. List personal information as requested.
   F. After you have completed the form, have another person review it for accuracy, spelling, general appropriateness and appearance.
   G. Submit the completed form to the employer.
   H. Arrange for a time to have that individual review your work.

5. The job interview. After completing the application form, the next important step is the job interview.
   A. Prepare yourself. Think of potential questions which the employer might ask.
   B. Do your homework. Research the firm's size, amount and type of business, locations, and annual report or financial statement.
   C. Double-check the exact date, time, and place of interview.
   D. Groom yourself, such as haircut, clean fingernails, etc.



   E. Arrive at the interview a few minutes earlier than your appointment. Many times it is useful to engage the secretary in conversation. Secretaries often have considerable influence on the hiring decisions of employers. They can also provide you with valuable information about the company, the potential job, or other insights.
   F. Be cheerful, relaxed, and polite during the interview.
   G. Listen very carefully, and speak clearly.
   H. Answer all questions to the point, but more than "yes" or "no". Some persons talk excessively when nervous. Others have a tendency to talk too little.
   I. Don't smoke cigarettes or chew gum.
   K. Make sure you know the position you are applying for.

L. During the interview, look directly at your interviewer. Eye contact is very important.
M. Ask questions of the employer. Remember, you are also interviewing them. It is best if you come to the interviewing situation prepared with some questions you would like to have answered.
N. Be sensitive to the subtle clues which indicate that the interview is over.
O. Thank the interviewer for the time spent with you at the end of the interview.

TAM #19 - Handout 1

Occupational Cluster Description Handout

1. Agri-business and Natural Resources

   This cluster is made up of jobs concerned with producing and processing materials for use as feed or clothing, in offices and home. These materials may also provide energy to run machinery and heat homes and factories.

2. Business and Office

   Jobs in this cluster deal with all aspects of running an office or business; keeping records, using different machines and equipment, and managing workers.

3. Communications and Media

   Careers in this cluster are related to the sharing of ideas and information. Media include any tools or devices used for this purpose. Newspapers, magazines, radio, television, telephone and telegraph are the major communications media.

4. Construction

   The construction cluster careers are those in the building industry. Construction jobs include those involved in building homes, offices and other buildings, roads, bridges, airports and dams.

5. Consumer and Homemaking Education

   This cluster of jobs includes those jobs which aim to teach the skills necessary to run a home -- like preparing food and making clothes. In addition to these, there are jobs which help people make the most of the many different household products, equipment and services available to them.

6. Environment

   The jobs in this cluster deal with protecting our natural resources and keeping our environment's air and water clean to protect people's health. Most of these jobs have been developed during the past 15 years.

7. Fine Art and Humanities

   The fine art and humanities cluster includes jobs that involve ideas and feelings. These are expressed by written and spoken words. Other materials used for expression include cloth, paper, paint, ink, concrete and so on. Some jobs express ideas and feelings through performances in dance, drama or music.

8. Health

   Jobs in this cluster deal with keeping healthy people from becoming ill and treating those who are ill to make them healthy again.

9. Hospitality and Recreation

   These careers help people plan and make use of their time off from work. Hospitality-type jobs are those in which people plan trips and provide transportation, while recreational-type jobs are those dealing with amusement and entertainment.

10. Manufacturing

    Jobs in the manufacturing cluster involve the processing of goods by machine or by hand. These products may be large or small, and are produced in quantities that range from many to a very few of certain items.

11. Marine Science

    This cluster of jobs deals with obtaining food and minerals from fresh and ocean waters. Some of these jobs deal with researching ways to use resources in lakes, rivers and seas, while others deal with designing and constructing structures people need below and on the surface of the water.

12. Marketing and Distribution

    Jobs in this cluster are the link between the producer and the consumer. Some necessary abilities in this field are: artistic talent, writing skills, physical stamina, and the ability to get along well with others.

13. Personal Services

    Personal services jobs help people live a better life. Making life more comfortable for others is the duty in some of these jobs, while others deal with making people more attractive. To do this type of work, one must enjoy doing things for others and be able to get along well with them.

14. Public Service

    Helping people is the theme of all jobs in this cluster. You must be able to work with people and understand their needs, problems and concerns. You must be able to talk with people and make them feel at ease, and have a real desire to make the world a better place in which to live.

15 Transportation

Moving people and goods from place to place. Jobs related to this cluster range from selling tickets to driving a truck, planning a route, or unloading a ship.

-- Adapted from MO View, 1984-85, pp. 10-11

TAM #19 - Handout 2

Career Deck Component Handout

1. Job Title: Found in D.O.T.

2. D.O.T.: Dictionary of Occupational Titles nine digit classification number such as xxx-yyy-zzz.

3. Cluster No.: USOE Training Number Holland's Occupational Classification - 3 Letter Code

4. The Job

   A basic description of the job duty is given. Pertinent questions are asked for the purpose of providing structure to the student and to stimulate the data-gathering process.

5. To Get The Job

   Four categories deal with aptitudes, interests, physical demands, miscellaneous requirements and other related comments. More information and further explanation pertaining to this job is found on Page Two, entitled "On the Job."

6. Things to Think About

   Additional in-depth comments are explored, including advantages, disadvantages, chances of advancement, fringe benefits and related occupations.

7. On the Job Description and Specific Job Duties

   These are given, but they may vary with the employer.

8. Earnings

   It should be understood that some of the information will vary with the employers. The average starting salary and the salary range is listed for the St. Louis metropolitan area. In most cases, the forty-hour week is in effect.

9. Employment Opportunities

   This section gives students an opportunity to learn the employment potential for various metropolitan areas. The Missouri View report provides specific data regarding net growth and replacement for a six-year period. This information should help a student judge whether or not to enter this field of occupational training.

10. Preparation and Training

    The general level of education needed, helpful high school subjects and a list of schools offering training are listed. The school courses related to the training should be beneficial, in that a student may realize some subjects are too difficult and, therefore, wish to choose another occupation. If students have early access to this information, they can prepare for the occupational training in advance. The training programs will include high schools, area vocational-technical schools and institutions offering training in the occupation for your region. Occasionally, an institution outside the region will be listed.

11. Where to Get More Information

The names and addresses of both regional and national sources are listed. A student can write for brochures, pamphlets and other information. The student is always referred to the counselor with the hope that this may initiate a commitment to the decision-making process..

-- MO-View, 1984-85, pp. 102-105

TAM #19 - Handout 3

Some Hints For Successful Interviewing and Job Searching

DO

1. Be neat and clean.
2. Be punctual.
3. Take a pen with you.
4. Take along a copy of your personal data information including pertinent dates relating to education and work experience.
5. Make good eye contact at the initial meeting with the potential employer.
6. Answer questions to the point. Avoid being either excessively short or long. Be sensitive to the signs that the interviewer will give you.

DONT

1. Smoke or chew gum.
2. Fuss with your hair.
3. Argue with or interrupt the interviewer.
4. Begin with questions about salary or wage.
8. Convey desperation.

-- Adopted from Gibson, 1976

Major Reasons Why People are Rejected for Jobs

1. Poor personal appearance
2. Poor attitude
3. Poor communications skills
4. Career indecisiveness
5. Over-emphasis on money
6. Unwillingness to work up from the bottom
7. Excuses made for a poor working record
8. Lack of tact
9. Immaturity
10. Poor manners
11. Criticism of past employers
12. Sloppy completion of application form
13. Poor eye contact, limp handshake
14. Tardiness
15. No work record
16. No display of interest in the company

-- Adopted from Gibson, 1976, p. 24

TAM #19 - Summary

1. **Review & Summary Activities**

   The purpose of this TAM is to lead you to understand different employment forms, the type of information required at most job interviews, and work attitudes expected in an employee. Also, it suggests the procedures you should follow and the tactics you should use in bringing your qualification and experience to the attention of prospective employers and selling your services convincingly.

2. **Review Questions -- Test yourself!**

   A. List four reasons for taking a self-inventory (strengths and weaknesses) before you look for a job.

   B. How can you show your appreciation to a person who has helped you in a job-hunting campaign?

   C. Why is it so important for you to prepare for a job interview?

   D. Why is a resume important for a person who is looking for a job?

TAM #19 - Post-assessment

Instructions:

1. Have the instructor review your activities and discuss any question(s) that still remain.
2. Complete post-test for TAM #19.
3. If the results demonstrate mastery, go on to the next activity assigned by the instructor. If less than successful, discuss with the instructor ways to improve your level of mastery.

TAM #19 - Post-test Self-Check

1. Complete post-test for TAM #19.
2. Have the instructor complete an evaluation form. Discuss his/her assessment.
3. If the result demonstrates mastery, go on to the next TAM or activity assigned by the instructor. If less than successful, see the instructor and plan what to do to improve your mastery.

Course: Introduction to Energy & Power Technology

Technology Activity Module #20

Today's Leaders for Tomorrow

by: Steve Murray

TAM #20: Today's Leaders for Tomorrow

Instructor Component

Activity Objectives: The purpose of this activity is to provide the students with an opportunity to develop skills in leadership and management. Students are to work cooperatively with others in the class.

Activity Competencies: By completing this TAM, the student will be able to:

1. Demonstrate leadership in individual activities related to the course.
2. Employ leadership skills in performing officer duties and guiding student organization activities.
3. Work cooperatively with others in leadership as well as subordinate roles.
4. Bring group activity to a successful conclusion.

Module Instructions

Introduction:

One effective method of preparing students for employment is that of simulation, by giving responsibility through job-related duties. This activity will present students with simulated work experience. It will allow students to develop work-related concepts that normally aren't developed until you are employed. Classroom activity will remain normal, with the exception of job titles and duties being assigned to students. The titles include manager, assistant manager, accountant, and foreman. These titles and accompanying duties will be turned over to different students each week until each student has experienced each.

Safety Considerations:

The safety considerations for this unit are the same as those which have been presented in general safety materials throughout the course. While these should be reinforced in this unit, no special considerations are required.

Needed Materials:

1. **Supplies Required**
   - A. ID Badges for Manager, Asst. Manager, Foreman, and Accountant
   - B. Clipboard with evaluation form (Handout 1)
   - C. Cards for a time clock
2. **Equipment/Machines/Tools**
   - A. Computer with printer
   - B. Word processing and spreadsheet software
   - C. Time clock - the time clock and materials may be purchased for $380 from:

EBSCO Curriculum Materials
Division of EBSCO Industries, Inc.
P.O. Box 262
Chelsea, AL 35043-0262
1-800-633-8623

3. **Handouts**

   Student component of TAM #20

4. **Instructional Resources**

   A. Books

   1. Bailey, Larry J. (1990). Working: Skills for a new age. Albany, NY: Delmar Publishers.
   2. Bohn, Ralph, Fales, James, MacDonald, Angus J.& Kuetemeyer, Vincent F. (1986). Special career skills. Energy, Power, and Transportation Technology, p. 388-396.
   3. Campbell, Richard & Thompson, Mary J. (1987). Working today and tomorrow. St. Paul, MN: EMC Publishing
   4. Chamberlain, Valerie M. & Eubanks, Eddye. (1986). Personal skills for home, school, and work. Mission Hills, CA: Glencoe/McGraw-Hill.
   5. Jones, Richard. (1990). Getting ready: Decisions, jobs, careers. Albany, NY: Delmar Publishers.
   6. Kelly, Joan M. & Bolz-Pattan, Ruth. (1988). Career skills. Mission Hills, CA: Glencoe/McGraw-Hill.
   7. Kimbrell, Grady & Vineyard, Ben S. (1989). Entering the world of work. Mission Hills, CA: Glencoe/McGraw-Hill.
   8. Kimbrell, Grady & Vineyard, Ben S. (1989). Succeeding in the world of work. Mission Hills, CA: Glencoe/McGraw-Hill.

Management/Logistics:

1. **Related TAMS**

   You may wish to refer to TAM 19 - Getting the Job/Scholarship You Want.

2. **Evaluation/Grading**

   The strength of this module is that it helps shift some of the responsibility for performance evaluation from the teacher to the student. As students evaluate other students, they can learn important lessons about the role of supervisors in job situations.

3. **Suggested Schedule/Time**

   A. Separate TAM - The time suggested is one to two weeks.

   B. Overlapping TAM - The time suggested for this TAM is the number of weeks that there are students in the class (Example: 25 students = 25 weeks). The time suggested is one to two weeks. This amount of time is required in order to allow each student the opportunity to experience each job.

Key Instructional Suggestions:

1. **Safety**

   In all laboratory-related activities, it is important to emphasize the wearing of safety glasses at all times

2. **Motivation**

   One excellent way of motivating students is to invite a guest speaker from a local business to speak with the class. Ask the person to address the kind of issues he or she faces in managing employees. Encourage a range of discussion, including employee responsibility (and lack of responsibility), tax and employee benefit issues, and the like. A second alternative would be to arrange for a field trip to a local business to talk with employers about the same kinds of issues.

3. **Prerequisite Information**

   Students can participate fully in this TAM without prerequisite information.

4. **Demonstrations**

   A. Using a word processing program
   B. Using a spreadsheet
   C. Using a time clock
   D. Operating a computer system
   E. Using the evaluation sheet

5. **Reinforcement**

   The activities of this unit provide excellent reinforcement for leadership goals which are inherent in many other courses across the curriculum. Coursework in business, management, economics, and government could be most directly reinforced.

6. **Attitudes**

   This TAM provides an excellent means for focusing on important interpersonal and leadership skills. The experience of evaluating peers provides an opportunity for students to practice a balance between being fair, yet conscientious, in their evaluations of other students. Additional benefits of group oriented activities include the development of the kinds of relational skills that are required to provide leadership in any organization or workplace setting.

7. **Remediation/Enrichment**

   Remediation: Role playing personnel department/manager addressing performance problem.

   Enrichment: Have the best students serve as consultants.

8. Summary & Review

In this TAM, we have learned about the responsibilities executives have in running an organization. We learned about the importance of cooperation and on-the-job communication. The following are to be reviewed:

A. Characteristics of individual leadership
B. Components of group leadership
C. Executive positions in a business organization
D. Executive responsibilities

9. Review questions & Answers

A. One of the most important career skills is ___________. (*leadership*)

B. The ___________ leader makes decisions without consulting others. (*autocratic*)

C. The ___________ leader consults others and then makes decisions. (*democratic*)

D. A leader is a person that ___________ others or shows the way for others to complete a task. (*directs*)

E. A(n) ___________ is a person who starts a business. (*entrepreneur*)

Date: ________ Class: ________ Name: ____________________________

TAM #20: Today's Leaders for Tomorrow - Pre-test

Instructions: Answer the following questions.

1. What do you feel is the primary activity a manager must perform in an organization?

2. It is very important to have leadership in an organization or business. Why is this statement correct?

3. What leadership qualities do you feel you possess?

Date: ________ **Class:** ________ **Name:** ______________________________

TAM #20: Today's Leaders for Tomorrow - Post-test

Instructions: Read each statement carefully and decide if the statement is **True** or **False** by placing a **T** or **F** in the blank.

1. ___ Leadership is a personality trait that directs others.

2. ___ Entrepreneur is a person who starts a business.

3. ___ Capital is a business process.

4. ___ Proprietorship is a business that is owned and operated by one person only.

5. ___ Corporation is a business that is owned by and operated by one person only.

6. ___ An autocratic leader determines what should be done and give orders without consulting a group for their opinion.

7. ___ A democratic is a leader that determines what should be done and gives the orders without consulting a group for their opinion.

Instructions: Place the word in the blank that completes the statement.

1. Two styles of leadership are:

   A. ______________________________

   B. ______________________________

2. A successful leader displays certain traits. Four characteristics of leaders are:

   A. ______________________________

   B. ______________________________

   C. ______________________________

   D. ______________________________

TAM #20: Today's Leaders for Tomorrow - Test Keys

TAM #20- Pre-test Answers

This pre-test is used to determine what the student knows. Answers will vary greatly. Instructors are encouraged to develop their own answers.

TAM #20 - Post-test Answers

1. T 2. T 3. F 4. T 5. F
6. T 7. F

1. Autocratic & democratic
2. Any four of the following:
   Understanding, honesty, fairness, tact, enthusiasm, resourcefulness

TAM #20: Today's Leaders for Tomorrow

Student Component

Introduction:

Leadership plays an important role in the development of technology. Without it, industry would be in bad shape. This module will allow you to develop leadership skills that normally wouldn't be learned in a school setting. Many of the principles and skills that you will use in this activity are used daily in industry.

Competencies: Following the completion of this TAM, you will be able to:

1. Demonstrate leadership in individual activities related to the course.
2. Employ leadership skills in performing officer duties and guiding student organization activities.
3. Work cooperatively with others in leadership as well as subordinate roles.
4. Bring group activity to a successful conclusion.

Module Overview:

Lee Iacocca! Larry Bird! Margaret Thatcher! Sam Walton! Elizabeth Dole! What do these individuals have in common? Leadership. Each of these individuals has demonstrated his or her leadership skills in the kinds of things he or she does best. They're outstanding. They make it look easy. But that's usually not the whole story. Most outstanding leaders have been through experiences where they learned how to become leaders. That's what the activities of this TAM are all about.

When you're looking at the kinds of careers that you think you might like to do, it is very important for you to be aware of your skills. One of the most important skills you can have is leadership. Leadership can be developed through many different classroom situations.

A leader is a person who directs others or shows the way for others to complete a task. The direction that a leader provides is very important to an organization. There are basically two styles of leadership: autocratic and democratic. The autocratic leader makes decisions alone without consulting others. A democratic leader makes decisions only after consulting others. Autocratic leadership exists mainly in smaller organizations, while democratic leadership exists mainly in larger organizations. A leader starts an activity, is a planner, and serves as a guide once the activity is in action. In order for a leader to be successful, he or she needs to develop traits such as understanding, honesty, fairness, tact, enthusiasm, and resourcefulness.

Characteristics of individual leadership are demonstrated in this activity. The manager, assistant manager, foreman, and accountant all have different responsibilities and roles in this activity (Figure #1).

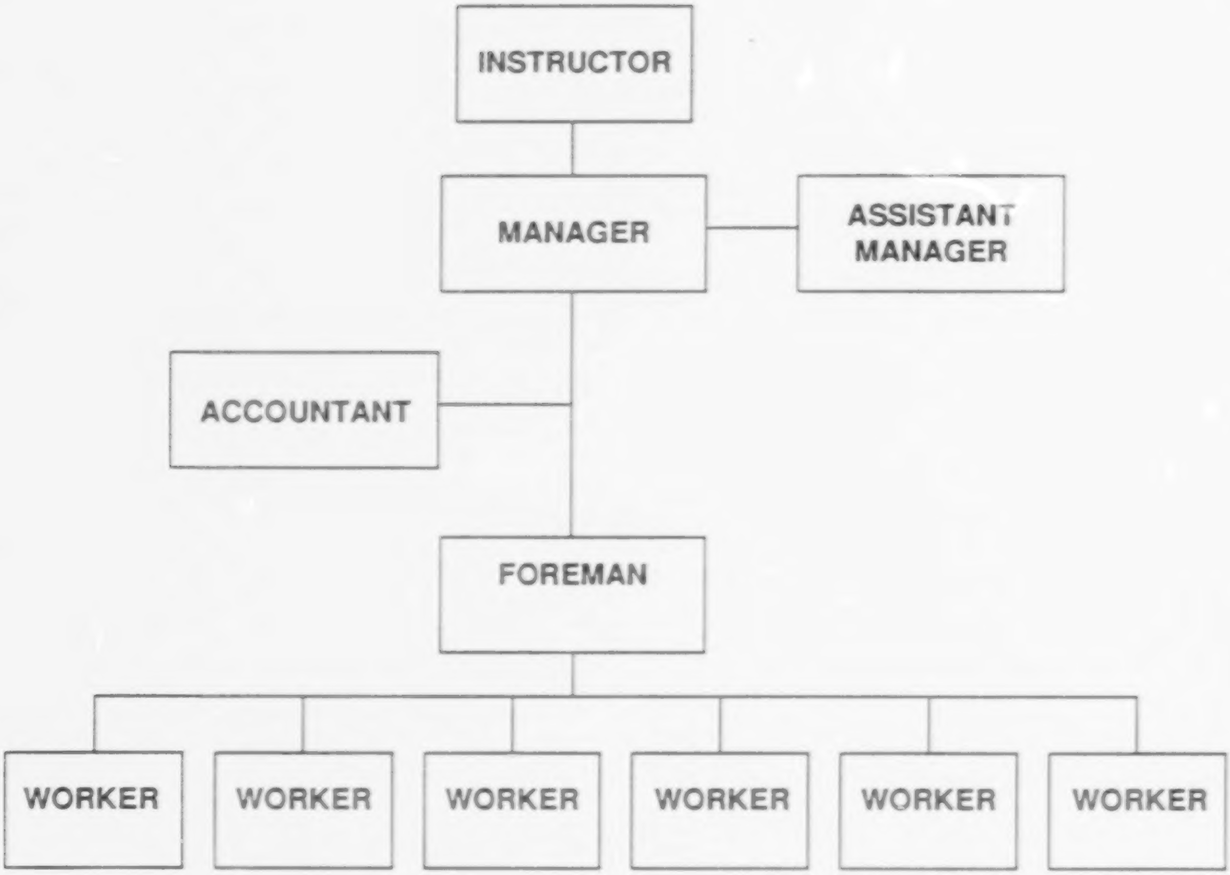

INSTRUCTOR
MANAGER
ASSISTANT MANAGER
ACCOUNTANT
FOREMAN
WORKER
WORKER
WORKER
WORKER
WORKER
WORKER

Figure #1 - Organizational Structure

This activity directly relates to group leadership. It demonstrates the importance of effective communication, conflict resolution, confidence, management, etc.

Activity Sequence:

A. Each week your instructor will select four students to serve as new executives.

B. Manager's Duties

The manager is to evaluate each student's activities during the class hour for a one week period. It is his/her responsibility to make sure everyone has something to do and that they do their duties correctly. The manager assigns a job (given by supervising teacher) to the student as necessary. All problems should be reported to the manager and if necessary, the manager will report the problem to the teacher.

C. Assistant Manager's Duties

The assistant manager's duties consist of assisting the manager. The assistant manager is to assist students with duties to ensure the duties are done properly. The assistant manager with the assistance of the manager assigns each student a maximum of 10 points for the class hour. The amount of points assigned is dependent upon each student's performance.

D. Accountant's Duties

The accountant's duties consist of keeping records and preparing reports for the foreman. If possible do this with a computerized spreadsheet program. The accountant prepares a payroll check for each student. These checks are to be signed by both the manager and accountant. Checks and deposits are to be recorded.

E. Foreman's Duties

The foreman's responsibilities include announcing and supervising clean-up time. Supervising clean-up includes assigning clean-up jobs, equipment pick-up, and proper goggle storage. The foreman assists the accountant, assistant manager, and manager as necessary. In the event that problems develop, the foreman represents the students. The quality of clean-up and the overall leadership ability demonstrated by the foreman are the criteria that the teacher will use to evaluate his/her performance.

Key Information:

1. Class Presentations

- All students are to participate in this activity.
- When students are assigned a job title, they will be evaluated by the supervising teacher. These students are to wear an ID badge.
- Students will receive points that will be translated into payroll check amounts.
- All checks must be turned in at the end of the activity to receive the points acquired.
- Each student may receive a maximum of 10 points per day depending upon his/her performance.
- Each student assigned a title may receive a maximum of 20 points per day by the supervising teacher.

2. Demonstrations

- Operating the computer
- Operating the word processing program
- Using a spreadsheet on the computer
- Using the time clock

3. Safety

Only procedures required by your instructor for the chosen activity.

4. Personal Activity

Interview several business executives regarding their responsibilities and ask if they have any advice for potential executives. Conduct a survey on the daily routines of selected business executives.

Glossary:

1. **Autocratic** -- A leader that determines what should be done and then gives the orders without consulting a group for their opinion.
2. **Capital** -- A form of input to a business; any form of wealth.
3. **Corporation** -- A business that is owned by several different individuals; the ownership of the business is expressed in stocks.
4. **Democratic** -- A leader that determines what should be done and then consults a group for their opinion.
5. **Entrepreneur** -- A person that starts a business.
6. **Leadership** -- A personality trait that directs others or shows the way.
7. **Proprietorship** -- A business that is owned and operated by one person only.
8. **Tact** -- The ability to relate with others in such a way to maintain good relationships or to avoid offense.

Needed Materials:

1. **Supplies Required**
    - A. ID Badges for Manager, Asst. Manager, Foreman, and Accountant
    - B. Clipboard with form (provided in useful forms section of guide)
    - C. Cards for a time clock

2. **Equipment/Machines/Tools**
    - A. Computer with printer
    - B. Word processing & Spreadsheet Software
    - C. Time clock (the time clock and materials may be purchased for $380 from:

      EBSCO Curriculum Materials
      Division of EBSCO Industries, Inc.
      P.O. Box 262
      Chelsea, AL 35043-0262
      1-800-633-8623

3. **Handouts**
    - A. Student Component of TAM #20

TAM #20: Today's Leaders for Tomorrow

Activity #1: Management System - Plan of Procedure

1. The instructor will distribute activity duty roster for executives.
2. All executives for the week one will wear ID tags (Figure #2).

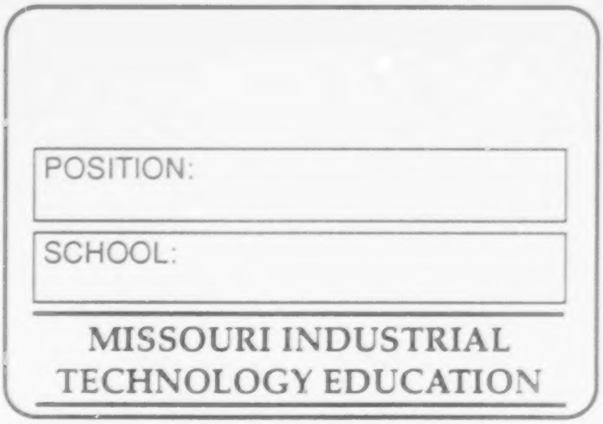


Figure #2 - ID Tags

3. The executives will conduct the following activities during the week:
   - A. Manager
     - Distribute job assignments to students.
     - Observe and evaluate all students
     - Correct (verbal) students when necessary.
     - Assign points to the students.
   - B. Assistant Manager
     - Assist manager in daily duties.
     - Assist the accountant when necessary.
     - Assist the foreman during cleanup management.
   - C. Accountant
     - Enter the daily points into the computerized spreadsheet.
     - On the last day of the week, calculate and write paychecks.
     - Print the computerized spreadsheet and give to manager.
   - D. Foreman
     - Assist students in any assigned job when necessary
     - Call clean-up at the proper time.
     - Observe all clean-up activities and make sure all procedures are done properly.
4. At the end of the week, distribute paychecks to the students.
5. Discussion over any problems encountered during the week, their solutions, and possible alternatives.

TAM #20 - Handout 1

Evaluation Form

Week ________ Month ________ Dates ________ to ________

NAME	Day 1	Day 2	DAY 3	Day 4	DAY 5	TOTAL PTS
2.						
3.						
4.						
5.						
6.						
7.						
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TAM #20 - Summary

Leadership is an important personality trait that each person can develop in any area. It is important to remember that an individual need not develop leadership skills in every aspect of their life or career. Often it is easy for one to attempt to lead in every activity. In some cases, it might be better to let someone else lead at certain times. Perhaps the most important concept of this TAM is to develop leadership skills in areas that you enjoy.

TAM #20 - Post-Assessment

1. Complete the post-test administered by your instructor.

Section III: Resources

Part 1: Books & Resources

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(800) 248-5474
(914) 328-9157

Provides training on how to use television, radio and other electronic equipment. Also produces various videos on electronics.

Laurin Publishing Company
P.O. Box 1164
Berkshire Common
Pittsfield, MA 01202-1146
(413) 499-0514

Textbooks on computer science, engineering, electronics, electronic communications, sciences, hobbies and crafts, aviation, automotive and other areas related to science technology.

McGraw-Hill Book Company/Gregg Division
1221 Avenue of the Americas
New York, NY 10020
(212) 512-4097

Trade and technical instructional materials in automotive, aviation, drafting, manufacturing, mechanical technology, construction, civil technology, tech math, tech physics, electricity and electronics.

Merrill Publishing Co.
P.O. Box 508
Columbus, OH 43216-0508
(614) 759-6600
(800) 848-1567

Variety of craft, engineering, science and vocational technology books.

Mid-America Vocational Curriculum Consortium
1500 W. Seventh Ave.
Stillwater, OK 74074
(405) 377-2000

Competency-based vocational instructional materials, "Exploring technology education" series. Includes information on communications, construction, energy, power, transportation, and manufacturing.

MIT Press
28 Carleton St.
Cambridge, MA 02142

Books and journals on humanities, sciences and technologies, engineering, etc.

Motorbooks International
729 Prospect Ave.
Osceola, WI 54020

Variety of automotive books for all vehicles, aerodynamics, air conditioning & heating, fuel systems & making fuel, electronic & electric vehicles, transmission & clutches, and so on.

National Academy Press
2101 Constitution Ave. NW
Washington, DC 20418
(202) 334-BOOK
(202) 334-3313
Fax: (202) 334-2793

Updated textbooks and research papers on education, industry & economics, technology, sciences and other general interest areas.

National Textbook Company
4255 West Toughy Ave.
Lincolnwood, IL 60646
(800) 322-4900

Various books on science, computer technology, education, management, and other textbooks regarding energy and power technology.

Osborne/McGraw-Hill
2600 Tenth St.
Berkeley, CA 94710
(800) 338-3987
(415) 548-2805

Textbooks on traditional engineering and computer sciences, lasers, communications, transportation and other fields related to energy and power technology.

Pergamon Press, Inc.
Maxwell House
Fairview Park
Elmsford, NY 10523
(914) 592-7700
Fax: -(914) 592-3625

Wide range of textbooks on energy, power, instrumentation & control, education, sciences, and engineering and technology. Journals of various interest, areas including systems and control , international mathematics, computers in simulation, automatica, etc.

Peterson's Guides Incorporated
166 Bunn Drive, Box 2123
Princeton, NJ 08543
(800) 338-3282
(609) 243-9111

Textbooks on education, careers ,sciences, energy and power, engineering and applied science. Provides services for cooperations such as training institutes and seminars.

Praeger Publishers
1 Madison Ave., 11th Floor
New York, NY 10010
(212) 685-5300

Various textbooks on communications, transportation, computer technology, sciences, education, electricity, electronics, automation etc.

Prakken Publications
416 Long Shore Drive
P.O. Box 8623
Ann Arbor, MI 48107
(313) 769-1211

Publishers of School Shop, Education Digest, and various textbooks, reference books and workbooks for industrial, technical and vocational educators.

Prentice-Hall
College Division
Englewood Cliffs, NJ 07632
(201) 592-2000

College textbooks on education, engineering, computers, electrical & electronic technology, physics/astronomy, and various other technology-related areas. Also, supplies manuals in the technology education field.

Rand McNally & Co.
P.O. Box 7600
Chicago, IL 60680
(312) 673-9100

Various books on engineering, sciences, education, humanities, energy and power and other disciplines.

Resources for the Future
1616 Street, NW
Washington, DC 20036
(202) 328-5086

A variety of books on energy, environmental economics and policy, minerals, education and other related fields of technology.

Richards Rosen Press, Inc.
29 East 21st Street
New York, NY 10010
(212) 777-3017
(800) 237-9932

Textbooks for students and teachers with science and technology careers such as education, high - tech , computer, electricity, aviation and many other fields related to energy and power.

Sage Publications, Inc.
275 South Beverly Drive
Beverly Hills, CA 90212

Professional social science, education, science & technology journals, periodicals and textbooks.

Sierra Club Books
730 Polk Street
San Francisco, CA 94109
(800) 624-7294
(415) 923-5603

Various textbooks on sciences, education, transportation, communications, electricity, electronics, and automotive.

STS Press
102 M.R.L.
University Park, PA 16802
(814) 865-1137

Books, journals, and reprints on technology, science and society.

Sybex Computer Books, Incorporated
2021 Challenger Drive, #100
Alameda, CA 94501
(800) 227-2346
(415) 523-8233

Textbooks on computer science and programs such as Lotus and CAD.

TAB Books, Inc.
Blue Ridge Summit, PA 17294-0580
(800) 233-1128

Wide range of science, engineering, craft, hobby, technology and general interest books.

The Bobbs-Merill Company, Inc.
4300 West 62nd Street
Indianapolis, IN 46268
(317) 298-5686

Wide range of craft, engineering, technical, and science & technology books.

The MacMillan Publishing Co.
866 Third Ave.
New York, NY 10022

Variety of textbooks on education, computers, engineering, physics/astronomy, electrical/electronic technology, and other realms.

The Oryx Press
2214 N. Central Avenue
Phoenix, AZ 85004
(602) 265-2651

Textbooks on sciences, computers, education, transportation, communications, and many other domains related to energy and power technology.

The Scientific Press
507 Seaport Court
Redwood City, CA 94063

Wide range of scientific, engineering, energy and power and many other technology related books.

U.S.G.P.O. - U.S. Government Printing Office
Superintendent of Documents
Washington, DC 20402
(202) 783-3238

Wide range of textbooks on Army, Navy, Airforce, Marines, commerce, communications, education, transportation, energy and many other fields.

Union Electric
1901 Chouteau Avenue
P.O. Box 149
St. Louis, MO 63166
(314) 621-3222

Electronics & electrical textbooks and related support materials.

University Associates, Inc.
8517 Production Ave.
San Diego, CA 92121
(619) 578-5900

Annually publishes a collection of human resource development exercises, simulations and activities.

Van Nostrand Reinhold Company
115 Fifth Ave.
New York, NY 10003

Engineering, craft, science and technology textbooks.

Vocational Marketing Services
18501 Carpenter Street
Homewood, IL 60430
(312) 799-6560

Unique collection of hard-to-find resources, books and videos of relevance to ITE.

Wadsworth Publishing Co.
10 Davis Drive
Belmont, CA 94002
(800) 354-9706
(415) 595-2350

Textbooks on sciences and technology realms such as computers, software, aviation, technical communications, technical writing, electricity, electronics and other fields of energy and power technology.

Part 4: Media Sources

Agency for Instructional Technology
Box A, 1111 West 17th St.
Bloomington, IN 47402
(812) 339-2203

This agency produces and distributes instructional videos, software and printed materials such as "Principles of Technology", "Applied Communication" and "You, Me and Technology". "Exploring Technology Education" is presently being developed. Many of their products are available for loan through the MVRC or for purchase from IML.

American Association for
Vocational Instructional Materials
120 Driftmier Engineering Center
Athens, GA 30602

Videos, tapes and instructional materials for technical subjects and vocational education.

American Gas Association
1515 Wilson Blvd., 9th Floor
Arlington, VA 22209
(703) 841-8582, 8676

Energy films, filmstrips, videotapes and resource list.

American Mining Congress
1920 N Street, NW, Suite 300
Washington, DC 20036
Darrell Williams/Jill Richardson
(202) 861-2800

Energy films, videotape and resource list.

American Petroleum Institute
156 William Street
New York, NY 10038
(212) 587-9660

Audio visual materials and films on petroleum and other areas related to energy and power.

American Science Center
Jerryco Inc.
601 Linden Place
Evanston, IL 60202
(312) 475-8440

Films/filmstrips, videotapes and media.

Americans for Energy Independence
1500 Wilson Blvd., Suite 1405
Arlington, VA 22209

Energy films/videotapes and resource list

Bergwall Productions, Inc.
106 Charles Lindbergh Blvd.
Uniondale, NY 11553
(516) 222-1111
(800) 645-3565

Filmstrips and videotapes on carpentry, cabinetmaking, Auto-Cad, electronics; filmstrips and video transfers in technology education, electronics, metal machines, small engines, vocational mathematics, electricity, technology education, and automotive technology. New series on manufacturing and exploring technology.

Bullfrog Films
Oley, PA 19547

Films on alternative energy sources, conservation and related topics.

Career Aids
20417 Nordhoff Street
Department ND
Chatsworth, CA 91311
(818) 341-2535

Multi-media materials for industrial and technical education, such as electricity and electronics, automotive technology, robotics and others.

Creative Learning Systems, Inc.
9889 Hibert, Suite E
San Diego, CA 92131
(800) 458-3880
(619) 566-3897

Reference books, software, Fischertechnik, Meccano and various films & videos for industrial and vocational education.

Curriculum Instructional Materials Center
(CIMC)
1500 West Seventh
Stillwater, OK 74074-4364
(800) 654-4502

Films, audios/slides, video cassettes/tapes and transferences on industrial and vocational education.

DCA Educational Products, Inc.
Kellers Church Rd.
P.O. Box 338
Bedminister, PA 18910
(215) 795-2841

Overhead transparencies, sound filmstrips, video cassettes and computer software for technical education.

DRW Educational Systems
P.O. Box 2491
Costa Mesa, CA 92628

Instructional media, films and tapes on electricity, electronics, and other areas related to technology.

Educator's Progress Service
214 Center Street
Randolph, WI 53956
(414) 326-3126

Publishes Educator's guide to: Free teaching aids, Free audio and video materials, Free films, Free Filmstrips, Free science materials, Free guidance materials, Free computer materials, etc.

EIA/CEG Electronics Industry Association
Dept. Ps
2001 Pennsylvania Ave.
Washington, DC 20006-1807

Has a wealth of information in the form of video cassettes, films, tapes, and pamphlets on electricity, electronics, and high technology.

ERDA Film Library
Technical Information/Center
P.O. Box 62
Oak Ridge, TN 37830

Films and filmstrips/slides on energy and other technology areas.

ESE
202 E. Kagy Blvd.
Bozeman, MT 59715
(406) 587-4383

Media & instructional resources on communications, electricity/electronics and modern technology.

Film Library & Video Service
1100 W. 42nd
Indianapolis, IN 46205
(217) 923-9352

Films, videos and tapes on energy and power and other technology related fields.

Films Incorporated
5547 N. Ravenswood Ave.
Chicago, IL 60640-1199

VHS videos on technology, science and contemporary issues.

Grant Wood AEA Film Library
4401 Sixth Street SW
Cedar Rapids, IA 52401

Catalogs, films, and filmstrips on vocational-technical education.

Hawkhill Associates, Inc.
125 East Gilman St.
Madison, WI 53703
(800) 422-4295

Science/Technology/Society sound filmstrips and video cassettes.

Industrial Arts Education Service
Virginia Department of Education
P.O. Box 6Q
Richmond, VA 23216

Films/filmslide, media & support resources on industrial education.

Instructional Materials Laboratory
Room 10, London Hall
University of Missouri-Columbia
Columbia, MO 65211
(800) 392-7217

16mm films, audio/visual programs, filmstrip/education kits, video cassettes/tapes, and transparencies for loan to Missouri educators. See MVRC.

Instructional Resources Center
Louisiana State University
Baton Rouge, LA 70803

Films, filmstrips, and videos on vocational education.

International Technology Education Association
1914 Association Drive
Reston, VA 22091-1502
(703) 860-2100

A continually enlarging compilation of resources related to technology education and it's implementation.
88-021 Washington State: Technology Education
88-071 Technology Education: Seven programs
88-072 Women in the machining industry
88-073 World Assembly interest sessions
88-074 Technological Studies
______ *A career for the 21st century (ITE Teacher Recruiting)*
______ *Technology Education: The New Basic*
______ *You can do it (Paxton student recruiting)*

Interplex Electronics, Inc.
70 Fulton Terrace
P.O. Box 1942
New Haven, CT 06512
(203) 624-3103

Films and filmstrips on energy and power.

J. Weston Walch
Publisher
Portland, ME 04104

Films and filmstrips/audio-visuals on vocational education.

Karol Media
P.O. Box 7600
Wilkes-Barre, PA 18773-9969

Films and video cassettes on vocational-technical education.

Lockheed-Georgia Company
Motion Picture Film Library
Zone 30, B-2 Bldg.
Marietta, GA 30060

Media Center
State Fair Community College
1900 Claredon Road
Sedalia, MO 65301
(816) 826-7100

Teaching materials in a wide range of subject areas, as well as audio-visuals and video tapes on vocational education.

Meridian Education Corporation
236 E. Front Street
Bloomington, IL 61701
(800) 727-5507

Videos, filmstrips, software and books on electricity, robotics, electronics, CAD, CAM, etc.

Metra Byte Corporation
440 Myles Standish Blvd.
Taunton, MA 02780
(508) 880-3000
Fax: (508) 880-0179

Instructional media and software on energy and power technology and others.

Missouri Vocational Resource Center (MVRC)
10 London Hall
University of Missouri-Columbia
Columbia, MO 65211
(314) 882-2883
(800) 392-7217

•AIT videos: Introduction to communication; Designing messages; Producing and transmitting messages; Evaluating messages; Overview of energy and power; Conversion and measurement of energy and power; Transmission, control and storage of power; Transportation systems; Overview of technology; People, technology and the environment.

•YMT videos: Living with technology, Decisions, decisions, decisions - information processing; The technology spiral; Energy for societies; Health and technology; Feeding the world - agricultural technologies; Communications; The changing romance - Americans and wheels; China, Japan and the West - Transfer of technologies; Population patterns and technology; Exploring space; Risk, safety and technology; Teachers in service YMT.

MoView
Missouri View Program
15875 New Halls Ferry Road
Florissant, MO 63031
(314) 831-7100

MoView is an acronym for vital information for education and work. It is an update source of information that is specifically geared toward job opportunities and salaries. It is a career information delivery system. MoView has a microfiche reader, microfiche with occupational and school information and an index of careers and clusters.

Modern Talking Picture Service
5000 Park Street N.
St. Petersburg, FL 33709
Film Scheduling Department
(800) 243-6877
(813) 541-5763
Fax: (813) 546-0681

Films/video cassettes on a wide range of education, technology and similar subjects.

NASA Technology Utilization Office
P.O. Box 8756
Washington International Airport
Baltimore, MD 21240

Films on aerospace careers, energy and power and many others.

National Audio Visual Center
Information Services GK
Washington, DC 20409
(310) 763-1896

Federal government audio-visual films, slides, video tapes, etc.

National Career Information Center
American Personnel & Guidance Association
Washington, DC 20009

Videos/tapes, films, and filmstrips/slides related to energy and power.

National Geographic Society
Educational Services
Department 87
Washington, DC 20036

Films and videos on a variety of technology and science-related areas.

NewsBan
58 Pine Street
New Canaan, CT 06840
(802) 875-2910

Films, instructional resources and software on energy and power.

NIMCO
National Innovative Media
Route 2, Box 301 B
Calhoun, KY 42327
(800) 962-6662
(502) 273-5050
Fax: (502) 273-5844

Various high quality videos, slides, filmstrips, cassettes and transparencies on refrigeration, appliance repair, air conditioning-heating, electricity, electronics, hydraulics, pneumatics, automechanics, autobody, small engines and diesels (autos & trucks).

Occupational Outlook Reprint Services
U.S. Department of Labor
Bureau of Labor Statistics
Washington, DC 20402

Ohio State University
Extension TV and Film Library
Room 26
2120 Fyffe Road
Columbus, OH 43210

Video cassettes and films and film slides in all areas of technology, including energy and power.

PBS Video
1320 Braddock Place
Alexandria, VA 22314-1698

Videos on a variety of technology-related subjects; impacts of technology, and others.

Pitsco
P.O. Box 1328
Pittsburgh, KS 66762

Syringes & plastic tubing for hydraulics; plastic gears, wheels, films & videos.

Prentice-Hall Media
150 White Plains Road
Tarrytown, NY 10591

Films, media and instructional resources on industrial and vocational education.

Science and Math Teaching Center
Michigan State University
East Lansing, MI 48824

Films and videos/tapes, and instructional resources.

Shell Film Library
1433 Sadlier Circle
West Drive
Indianapolis, IN 46239

Instructional media sources and films on vocational-technical education.

SIGI Plus
Education Testing Service
P.O. Box 6403
Princeton, NJ 08543-5072

SIGI Plus is a special tool that can help you plan your career. It is an advanced computerized guidance system which examines work-related values while incorporating personal interests and skills. It creates, also, a list of occupations a student may want to consider, and will provide career information about these or other occupations the student is considering.

Teaching Aids, Inc.
P.O. Box 1798
Costa Mesa, CA 92628-0798
(714) 548-9321

Instructional media and software, tests in technology, machine operation, safety, etc.

Texas Power and Light
Public Service Department
P.O. Box 226331
Dallas, TX 75266

Films and filmstrips on energy and power.

The Futurist Bookstore
World Future Society
4916 St. Elmo Avenue
Bethesda, MD 20814

Future-oriented books and media dealing with technology, education, occupations, etc.

TVO Video, 1990 Curriculum Catalog
143 West Franklin Street, Suite 206
Chapel Hill, NC 27516

U.S. Council for Energy Awareness
1776 I Street, NW, Suite 400
Washington, DC 20006-0770
(202) 293-0770

Energy films/videotapes and resource list.

U.S. Department of Energy
Division of Public Affairs
Washington, DC 20585
(202) 586-6827
(800) 523-2929, 233-3071

Energy films and videotapes.

UMC Film Library
Academic Support Center
505 East Stewart Rd.
University of Missouri-Columbia
Columbia, MO 65211
(314) 882-3601

Films and filmstrips, slide/tape presentations, instructional videotapes, and teaching materials in a broad range of areas.

Unilab, Inc.
9102-1 Industry Drive
P.O. Box 837
Manassas Park, VA 22111
(703) 330-1997

Films, videotapes/cassettes and transferences.

Union Electric Company
(Union Electric Films)
1901 Chouteau Ave.
P.O. Box 149
St. Louis, MO 63166
(314) 554-2480

Films, literature, multimedia kit, references, speakers, and videotapes. Ask for: Energy Education Teacher Resources Guide.

United World Free Film Service
221 South Park Avenue
New York, NY 10003

University of Colorado
Educational Media Center
360 Stadium, Gate 11
Campus Box 379
Boulder, CO 80309-0379

Film strips, videos and films, and teaching materials in all fields of technology.

University of Illinois
Visual Aids Service
1325 S. Oak Street
Champaign, IL 61820

Films, filmstrips, videos, and slides on vocational education.

University of Kansas
Audio Visual Center
746 Massachusetts Street
Lawrence, KS 66044

Video, films and filmstrips, and materials in all technological areas.

Video Outreach
c/o JN Company
P.O. Box 388
Woodbury, NY 11797

Provides, courtesy of Phillips Petroleum, The search for solutions (nine videos) and American enterprise (five videos). Reproduction permitted.

Part 5: Resource Centers

Advanced Center for Technology Training
(ACTT)
31000 Northwestern Highway
P.O. Box 9079
Farmington Hills, MI 48333-9079
(800) 544-4730
(313) 737-4730

Provides training and services to educators along with catalogs and various technology instructional resources.

Aerospace Education Foundation
1501 Lee Highway
Arlington, VA 22209-1198
(703) 247-5839

Training, services, and various instructional resources pertaining to aerospace.

Air Conditioning and Refrigeration Institute
(Heating & Cooling)
1501 Wilson Blvd.
Arlington, VA 22209
(703) 524-8800

Provides information and advice to private, public, vocational, technical, and industrial schools regarding heating, air conditioning, and refrigeration. Also distributes curriculum guides and textbooks to those schools conducting the National Confidency examination.

American Council for an Energy Efficient
Economy
1001 Connecticut Ave., NW
Suite 535
Washington, DC 20036
(202) 429-8873

Research organization into energy efficient technology, transportation, power, environment, utilities, appliances, lighting and equipment, conservation research and development, and consumer guides. Also publishes some textbooks in the areas of energy, power and transportation technology.

American Petroleum Institute
2101 L. Street, NW
Washington, DC 20005

Catalogs, media and instructional resources.

Aviation Education
Department of Transportation/Federal
Aviation Administration
Office of Aviation Policy
Washington, DC 20591
(202) 366-4000

Offers a kindergarten through 12th grade curriculum series that introduces beginners to the world of aviation.

Aviation Education Materials
Beech Aircraft Corporation
Education Department
Wichita, KS 67201
(316) 681-7111

Provides information on current products, aeroplanes, space crafts, starships, as well as instructional resources for education.

Aviation Education Programs
Cessna Aircraft Company
P.O. Box 1521
Wichita, KS 67201
(316) 685-9111

An abundant resource on international education packages, instructor guides, posters, instruments, and air craft models.

Center for Education & Training for Employment
Ohio State University
1960 Kenny Road
Columbus, OH 43210
(800) 848-4815

Large collection of vocational education resources.

Center for Implementing Technology
Education (CITE)
Department of Industry and Technology
Ball State University
Muncie, IN 47306
(317) 285-5659

Collects, produces and disseminates technology education activities. The MVRC subscribes, and is therefore available for review from this service.

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CNN, Turner Educational Services
One CNN Center
P.O. Box 105366
Atlanta, GA 30348
(404) 827-2145, Gary Rowe

Media and instructional resources on industrial, technical and vocational education.

Compu-Serve
P.O. Box 202102
Columbus, OH 43220
(800) 848-8990
(614) 457-8650
Fax: (614) 457-0348

An information service on data bases, membership, etc.

Creative Learning Systems, Inc.
9899 Hibert, Suite C
San Diego, CA 92131

New instructional resources in technology education; conduct training seminars, materials and equipment, catalogs.

Curriculum Instructional Materials Center (CIMC)
1500 West Seventh
Stillwater, OK 74074-4364
(800) 654-4502

Curriculum guides, catalogs, media and many instructional resources.

Department of Energy
Office of Scientific & Technical Information
P.O. Box 62
Oak Ridge, TN 37831

Films, other materials and services pertaining to energy.

Department of Transportation
Federal Aviation Administration
Washington, DC 20591

FAA aviation education material, demonstration aids for aviation education: how the first flight was made, the main parts of an airplane,and teacher guides for aviation education.

Edison Electric Institute
1111 19th St., NW
Washington, DC 20036
(202) 778-6400

General materials and information pertaining to electricity.

EKI
16631 Noyes Avenue
Irvine, CA 92714
(714) 833-8711
Fax: (714) 833-8816

Provides training to individuals in various programs in electricity, electronics, and communications.

Electrification Council
1111 19th St., NW
Washington, DC 20036

Provides training courses for industry members in energy management, fundamentals of industrial management and commercial lighting, industrial and commercial power lighting, etc.

Energy and Education Action Center
Reporter Bldg, Rm 514
300 7th St. SW
Washington, DC 20202

Gemini Educational Systems
322 West Old Plank Road
Columbia, MO 65203

Enrichment company for developing curriculum guides; conducts consultation workshops and develops TAMs.

General Motors
Attn: John Thorns
3700 S. Lindbergh Blvd.
St. Louis, MO 63127
(314) 965-5666
Fax: (314) 965-4163

Provides free technology training to GM dealerships and educators in Missouri along with an automotive magazine for automotive instructors.

Guidance Information Center
Academy Avenue
Saxtons River, VT 05154

Assortment of media and instructional resources on careers in energy and power and technology related fields.

Illinois Vocational Curriculum Center (IVCC)
Sangamon State University F-2
Springfield, IL 62709
(800) 252-8533

A variety of trade and industry-related instructional resources in electricity, electronics, communications, transportation, and automotive.

Institute for Scientific Information
3501 Market Street
Philadelphia, PA 19104

Various instructional resources on science and technology.

Invent America, U.S.
Patne Module Foundation
510 King Street
Alexandria, VA 22314
(703) 684-1836

Provides a national education program on invention and competition, including problem-solving techniques from kindergarten through 12th grade, and other instructional resources such as books, guides, etc.

JETS, Inc.
Junior Engineering and Technology Society
1420 King Street, Suite 405
Alexandria, VA 22314
(703) 548-5387

Junior Achievement
45 Clubhouse Drive
Colorado Springs, CO 80906
(303) 540-8000

KIDSNET
Computer Clearinghouse on Radio and TV
6856 Eastern Ave., Suite 208
Washington, DC 20012
(202) 291-1400

Media collection and other resources for enhancing elementary and secondary education.

Mathematics and Science Education Center
316 Clark Hall-University of Missouri-St. Louis
8001 Natural Bridge Road
St. Louis, MO 63121

- OZARK
  Mr. Hugh Brewer
  Route 2, Box 38A
  Republic, MO 65738
  H (417) 732-6269
  W (417) 887-0653
- CENTRAL
  Mr. David Jungmeyer
  Route 2, Box 164A
  California, MO 64037
  H (314) 796-3764
  W (314) 796-4911
- NORTHCENTRAL
  Ms. Maureen Funk
  Route 4, Box 344
  Macon, MO 63552
  H (816) 385-6164
  W (816) 385-2711
- WESTCENTRAL
  Mr. Charlie Brock
  Route 2, Box 190
  Higginsville, MO 64037
  (816) 584-2363
- NORTHWEST
  Ms. Susan Pryor
  Route 2, Box 261
  Holt, MO 64048
  H (816) 296-3285
  W (816) 528-4202
- WESTERN
  Ms. Peg Young
  4505 W 74th Place
  Prairie Village, KS 66208
  (913) 362-4818
- MERP
  658 Amelia
  Webster Groves, MO 63119
  (314) 962-7752

A variety of multi-media materials and updated instructional resources on energy, solid waste, composting and recycling.

Minnesota Educational Computing Consortium
(MECC), Department 2B
3490 Lexington Ave, North
St. Paul, MN 55126
(800) 228-3504

Educational computer software and related items.

Missouri Energy Resource Project (MERP)
7838 Big Bend
Webster Groves, MO 63119
(314) 962-7752

Missouri Vocational Resource Center (MVRC)
10 London Hall
University of Missouri-Columbia
Columbia, MO 65211
(314) 882-2883
(800) 392-7217

Provides free (loan) services to Missouri educators; assortment of print, audio-visuals, curriculum guides, texts, manuals, workbooks, catalogs and various media sources.

Mountain Plains Regional Resource Center
Drake University
Des Moines, IA 50311
(800) 443-7253
(515) 271-3936

Gives help to local education agencies; in-service training, catalogs, media and instructional resources, particularly in special education-related topics.

NASA
Scientific and Technical Information Facility
P.O. Box 8757
Baltimore/Washington-International Airports, MD 21240
(301) 859-5300

- Regional center serving Missouri
  Public Affairs, CA20
  NASA Marshall Flight Center
  Marshall Space Flight Center, AL 35812
  (205) 544-6527

Media and instructional resources.

NASA Electronics Research Center
Educational Program Office
Cambridge, MA 02139

Large collection of electrical/electronics resources.

NASA Lewis Research Center
Teacher Resource Center
Mail Stop 8-1
Cleveland, OH 44135
(216) 433-2017

Collection of media and instructional resources.

NASA Lewis Research Center
Office of Educational Services
21000 Brookpark Road
Cleveland, OH 44135

Large number of media and instructional resources.

National Aeronautic & Space Administration (NASA)
Director of Secondary Programs
NASA Headquarters, Code XE
400 Maryland Avenue
Washington, DC 20540
(202) 453-1110

Collection of media supporting materials and instructional resources.

National Aeronautics and Space Administration
(For Printed Materials)
Educational Publications
Code FAD -1
Washington, DC 20546

National Center for Educational Media and Materials for the Handicapped (NCEMMH)
Ohio State University
Faculty of Exceptional Children
1945 North High Street
Columbus, OH 43210

A variety of media support materials including tools and other equipment.

National Energy Foundation
5160 Wiley Post Way, Suite 200
Salt Lake City, UT 84116
(801) 539-1406

National Instructional Center for Special Education Materials (NICSEM)
University of Southern California
University Park
Los Angeles, CA 90007

Media-supporting materials and equipment, as well as instructional resources. Large collection of special education media.

National Technical Information Service (NTIS)
United States Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

Listing of United States government-related technical information and databases.

Odyssey of the Mind
Creative Learning Systems, Inc.
9889 Hibert Street, Suite E.
San Diego, CA 92131
(800) 458-2880

Osborne McGraw-Hill
McGraw-Hill Information-Services Company
Computers & Communications
Information Group
2600 Tenth Street
Berkeley, CA 94710

Provides services to teachers & others; media and instructional resources.

Pace, Inc.
9893 Brewers Court
Laurel, MD 20723
(301) 490-9860
Fax: (301) 498-3252

Provides teacher training, audio-visual training programs, kits, handbooks, and training aids, surface mount technology trainers and programs.

Petroleum Extension Service
The University of Texas-Austin
BRC Box 413, 10100 Burnett Rd.
Austin, TX 78758
(512) 471-3163
Telex: 767161

Coordinates and operates technology schools for training and develops curriculum.

Philips Petroleum
Attn: Cheryl Finkenbinder
16 A3, Philips Building
Barplesville, OK 74004
(800) 331-0961
(918) 661-6600

Classroom quantities of petrochemical oil industry materials related to energy & power technology.

Rural Electricity Company (REA)
2722 E. MacTherty
Missouri Electric Cooperative
Jefferson City, MO 65101
(314) 635-6857
(314) 696-3654

Provides update on conservation of land and hydroelectric power for rural development & electrification administration.

Shell Educational Services
Shell Oil Co.
P.O. Box 2463, Rm. 1541
One Shell Plaza
Houston, TX 77001
(713) 241-6161

- (For Printed Materials)
  Public Relations Dept.
  50 West 50th Street
  New York, NY 10020
  (212) 975-9500

SMEAC
Information Reference Center, Room 310
Ohio State University
1200 Chambers Road
Columbus, OH 43212

Energy conservation and educational information.

Solar Energy Research Institute
1617 Cole Boulevard
Golden, CO 80401
(303) 231-1000

St. Louis Science Center
5050 Oakland Avenue
St. Louis, MO 63110
(314) 289-4409

Collection of media and instructional resources.

Technical Education Research Center
1696 Massachusetts Ave.
Cambridge, MA 02138

Hands-on media and instructional resource materials.

Technology Education Development Unit
c\o John Martin and Martin Coleman
Salford University
Salford, M5 4WT, UL
United Kingdom

The technology education development unit is involved in technology resource development for teachers and pupils. It is particularly interested in the possibilities of exchanging ideas and comparing approaches, staff exchanges to learn about technology approaches in each other's centers and development of resources that would be valuable in both the UK and the collaborator's country.

The American Nuclear Society, Inc.
555 N. Kensington Ave.
La Grange Park, IL 60525
(312) 352-6611

The Educational Resources Information Clearinghouse on Handicapped and Gifted
Council for Exceptional Children
1920 Association Drive
Reston, VA 22901

Various collection of instructional resources in vocational, technical and industrial education.

The Renewable Energy Coordinating Council
Solar Research & Education Foundation
1730 N. Lynn St., Suite 610
Arlington, VA 22209
(703 524-6100

The Vocational Studies Center
University of Wisconsin-Madison
Publications Unit
964 Educational Sciences Building
1025 West Johnson Street
Madison, WI 53706
(608) 263-2929

Collection of vocational education resources.

U.S. Atomic Energy Commission
P.O Box 62
Oakridge, TN 37830

Various booklets on Atomic energy: accelerators, power from radioisotopes, spectroscopy, controlled nuclear fusion, etc.

U.S. Council for Energy Awareness
17761 Street, NW, Suite 400
Washington, DC 20006-2495
(202) 293-0770

Provides services, seminars, catalogs, and instructional resources in all areas of energy and power.

U.S. Department of Energy
Federal Energy Regulatory Commission
Office of External Affairs
825 N. Capitol St., NE, Rm 2214
Washington, DC 20426
(202) 357-8055

Atoms to electricity, nuclear power plant safety: Source terms; Nuclear power plant safety: Operations; Careers in energy industries; Understanding radiation; Nuclear power in space; Radioisotopes: Today's applications; Answers to questions; Nuclear power plant safety: Design and Planning; Usable electricity from the sun; Converting coal to liquid fuels; and New technologies for burning coal.

Union Electric
1901 Chouteau Avenue
P.O. Box 149
St. Louis, MO 63166

Provides literature, guest speakers, seminars, video and multi-media. Ask for: Energy education teachers resource guide.

Part 6: Sample Suppliers

A. C. Spark Plug Div.
General Motors Corp.
1300 N. Dort Highway
Flint, MI 48506

Wall chart - spark plug conditions, service manuals - fuel pump, hydraulic valve lifters, engine tune-up and spark plug.

Acme Chain Division
Attn: Lloyd Fraser
North American Rockwell
821 Main Street
Holyoke, MA 01040

Films, brochures, catalogs and samples.

Advanced Center for Technology Training (ACTT)
31000 Northwestern Highway
Farmington Hills, MI 48018
(313) 737-4730

Technology literacy, robotics and automation training programs, simulators, workstations and ORT modules.

Advanced Microsystems Technology
P.O. Box 1942
Bowling Green, KY 42102
(502) 782-1888

Software program modules focusing on electrical symbols, components, introduction color codes, circuits, resistance, etc.

Air Research
402 South 36th St.
Phoenix, AZ 85034

Wall chart - gas turbine engine.

All Electronics Corp.
P.O. Box 20406
Los Angeles, CA 90006
(213) 380-8000

Retail and surplus components, switches, relays, keyboards, transformers, computer-grade capacitors, cassette player/recorder mechanisms, etc. Mail order and retail stores in L.A. area. Regular catalog.

Allied Electronics
AE Division, Inc.
401 E 8th Street
Fort Worth, TX 76102

Electronic components, robotic & computer kits and technology education products.

Alltronics
15460 Union Ave.
San Jose, CA 95124
(408) 371-3053

Mail order. New and surplus electronics.

Alpha Products
7904-N Jamaica Ave.
Woodhaven, NY 11421
(800) 221-0916

Mail order. Stepper motors and stepper motor controllers, ICs and complete boards.

Alpha Supply Company
248 Route 181
Lake Hopatcong, NJ 07849

Multibotics-inexpensive robotic teaching tools for several popular computers.

American Gas Association
Educational Services
1515 Wilson Blvd.
Arlington, VA 22209

Gas energy appliances and technology education teaching materials.

American Trucking Association, Inc.
Educational Services Department
1616 P Street, NW
Washington, DC 20036

How trucks serve you, travel fun with trucks and the things you'll want to know about them.

Analytic Methods
1800 Bloomsbury Ave.
Ocean, NJ 07712
(201) 922-6663

Mail order. Integrated circuits, LEDs, surplus parts, computer cables.

Anilam Electronics Corp.
5625 NW 79th Ave.
Miami, FL 33166
(305) 592-2727

CNC controllers and machines.

Applied Educational Systems, Inc.
1273 North Church Street
Moorestown, NJ 08057
(609) 727-1994

Developing training systems in automotive, HVAC, hydraulics, and process control, including educational programs for administrators.

Arrow Safety
1007 Monitor St.
LaCrosse, WI 54603
(800) 284-2147

Safety products - protective glasses, goggles, hearing protection: first aid supplies, eye wash station, safety signs, cans, asbestos removal equipment, respirators, welding supplies, shop coats, fire blankets and extinguishers.

B.B. Micro
P.O. Box 280298
Dallas, TX 75228
(214) 271-5546

Mail order. Components, 31.2 MHz crystal, 300 kHz crystal, 300 kHz crystal, UARTs. Most popular TTL, CMOS, and linear ICs, construction parts.

Baldor Electric Co.
Attn: John McFarland
P.O. Box 2400
Fort Smith, AR 72902
(501) 646-4711

Technical training materials, brochures, and catalogs on electric motors.

Barrett Electronics
5312 Buckner Dr.
Lewisville, TX 75028

Mail order electronic surplus: components, power supplies, computer-grade capacitors.

BCD Electro
P.O. Box 830199
Richardson, TX 75083-0199
(214) 343-1170

New and surplus electronic parts, computer boards, power supplies, IC's, and components.

Boston Gear
14 Hayward Street
Quincy, MA 02171
(800) 343-3353
(617) 328-5960 in MA

Gears and power transmission components. Available through local Boston Gear distributor.

Briggs and Stratton Corp.
2711 N. 13th Street
Milwaukee, WI 53201
(414) 259-5333

Booklet - Theory of operation of small gas engines. Service manual - Briggs and Stratton engines. Engines (at reduced school prices).

Brodhead-Garrett Company
223 S. Illinois Ave.
Mansfield, OH 44905
(800) 321-6730

Equipment to teach industrial arts in the traditional and new technology methods. Tools, machinery and supplies and modern teaching aids offered, 1000 page catalog.

C & H Sales Company
2176 East Colorado Blvd.
Pasadena, CA 91107
(800) 325-9465
Fax: (818) 796-4875

Catalogs, electrical and electronics equipment.

Career Aids, Inc.
20417 Nordhoff
Chatswortth, CA 91311
(818) 341-2535

Media materials for industrial and technical education such as woodworking, shop safety, CAD/CAM and drafting, metalworking and welding, automotive technology, electricity and electronics, manufacturing and plastics, robotics, and desktop publishing/printing shop. Also materials for workfare programs such as IBM, Apple, VHS, filmstrips and cassettes.

Career Research
65 W. Gordon Ave.
Salt Lake City, UT 84107
(800) 562-7267
(801) 266-1441

Products in electricity/electronics technology, laser technology, electronics assembler, and many other electronic kits and technology education products.

Centuri Flying Model Rockets
P.O. Box 1988
Phoenix, AZ 85001

Aeroplanes, space crafts models and technology education support materials.

Champion Spark Plug Co.
P.O. Box 910
Toledo, OH 43601

Teacher kit - includes: 1. Wall charts of basic ignition system, 2. Film loan chart and folders about free films, 3. Booklets: Facts About Spark Plugs, Tune-Up chart for Autos, Automotive Service Manual.

Chaney Electronics
P.O. Box 4116
Scottsdale, AZ 85261
(602) 451-9407

Suppliers of over 150 electronic kits.

Chown Hardware and Machinery
P.O. Box 2888
Portland, OR 97208
(800) 547-1930

Maintenance hardware, portable electric tools, hand tools and woodworking machinery for over 100 years.

Chrysler Corporation
1200 Chrysler Drive, Highland Park
Detroit, MI 48288
(313) 756-0136

Wall charts (black & white): 1. Wall charts of basic ignition system, 2. Film loan chart and folders about free films, 3. Booklets: Facts About Spark Plugs, Tune-Up chart for Autos, Automotive Service Manual.

CNC Software, Inc.
7212 S. Wapato
St. Tacoma, WA 98409
(206) 474-1850

Master CAM industrial CAM package; 3-D milling, turning, internal drawing package, Cadlinks - AutoCAD, CADKEY, Versacad, Anvil.

Comprehensive Guides
7507 Oakdale Ave.
Canoga Park, CA 91306
(818) 718-8475

Robot parts and kits, ready-make movie kits, Fishertechnik kits, robot constructions plans and books. Catalog available.

Computer Parts Mart
3200 Park Blvd.
Palo Alto, CA 94306
(415) 493-5930

Mail order surplus regular catalog. Good source for stepper motors, lasers, power supplies, and incremental shaft encoders (pulled from equipment).

Cybernetic Micro Systems
445-203 San Antonio Rd.
Los Altos, CA 94022
(415) 949-0666

IC manufacturer; motor control, stepper motor control.

D & M Computing, Inc.
1010 32nd Ave.,
South Moorhead, MN 56560
(218) 233-5172

CAD/CAM packages operating on IBM or Apple IIE, computer, electronic & robotics kits.

DAK Industries, Inc.
8200 Remmet Ave.
Canoga Park, CA 91304
(800) DAK-0800
Fax: (818) 888-8220

Datashow projection system in IBM disc computers and Apple II series computers.

David Brown Gear Industries
Attn: T.G. Ryssen
26 Howden Road
Scarborough, Ontario
Canada

Set of sheets explaining specific circuits (good for transparencies).

Dick Smith Electronics
P.O. Box 2249
Redwood City, CA 94064-2249
(415) 368-8844

Mail order and retail store. Most popular TTL, CMOS, transistors, and linear ICs, ultrasonic transducers, Motorola 14457 and 14458 remote control ICs, PC-compatible boards and sub-systems, wire-wrapping supplies and tools, R/C toys and receiver/transmitters.

Digi-Key Corp.
701 Brooks Ave., S.
P.O. Box 677
Thief River Falls, MN 56701-0677
(800) 344-4539

Mail order. Discount components ranging from crystals to integrated circuits to resistors and capacitors in bulk.

Edmund Scientific
101 E. Gloucester Pike
Barrington, NJ 08007
(609) 547-3488, 573-6250

A wide array of hobbyist, scientific and technological supplies, materials, equipment, tools, instruction sets and kits, optics, mechanics, physics, chemistry, electronics, etc. Also, lenses, new & surplus motors, gadgets, for robot building and a wide variety of materials for technology activities.

Erac Co.
8280 Clairemont Mesa Blvd., Suite 117
San Diego, CA 92111
(619) 569-1864

Mail order and retail store. PC-compatible boards and sub-systems, surplus computer boards, computer power supplies and components.

Eshed Robotics, Inc.
45 Wall St.
Princeton, NJ 08540
(609) 683-4884

Robotics, robotic training integration with CNC, real-time work cell control and machine vision products, textbooks, workbooks, instructor manuals, AV materials, hardware and software.

Estes Industries, Inc.
Penrose, CO 81240
(303) 372-6565

Model rocketry supplies including the space age teaching aid; teachers manual; course guide: model rocketry in middle school/junior high school (grades 6-9); course guide: model rocketry in high school (grades 9-12); industrial arts; teachers manual for model rocketry; learning guide for model rocketry; learning guide for model rocket launch system; technical note TN-5 elementary mathematics of model rocket flight; and the laws of motion & model rocketry.

Fisher America, Inc.
175 Route 46 West
Fairfield, NJ 07006
(800) 631-7131

Electronic and robotic components & technology education supplies. Fishertechnik computing kit. Fishertechnik interface of Apple, Commodore, IBM, Atari-ST, Amiga and Amstrad CPC.

Galted Specialities Co.
827 E. Evelyn Ave.
Sunnyvale, CA 94086
(408) 732-1573

Mail order and retail stores. New and surplus components, PC-compatible boards and subsystems, ceramic resonators (surplus item), power supplies, most popular ICs, transistors, etc.

Gates Energy Products
1050 South Broadway
Denver, CO 80217

Lead-acid rechargeable batteries.

Gateway Electronics
8123-25 Page Blvd.
St. Louis, MO 63130
(314) 427-6116

Supplies electronics including PC boards, circuits, electronic devices, electronic oscillators, instruments and measurements, and other devices related to energy and power.

GIL Electronics
P.O. Box 1628
Soquel, CA 95073

Hardware, software, computer parts.

Globe Union Battery
5757 N. Green Bay Ave.
Milwaukee, WI 53201

Gel/Cell rechargeable batteries.

Graves-Humphreys
1948 Franklin Rd.
Roanoke, VA 24033
(800) 631-0158

CAD/CAM packages operating on IBM or Apple IIe computers. Safety and machine maintenance videos, general supplies.

Graymark
Box 5020
Santa Ana, CA 92704
(800) 854-7393

Electronic and robotic kits, components and instructional materials.

H & R Corporation
A. Herbach & Rademan Co.
401 E. Erie Ave.
Philadelphia, PA 19134-1187

Surplus mechanical components. Excellent source for heavy-duty DC gear motors.

Hal-Tronix, Inc.
12671 Dix-Toledo Highway
P.O. Box 1101
Southgate, MI 48195
(313) 281-7773

Mail order. Surplus computers, computer components, PC-compatible boards and subsystems.

Hearlihy & Co.
714 W. Columbia St.
P.O. Box 869
Springfield, OH 45501
(513) 324-5721
(800) 622-1000

CAD, CAM, industrial technology computer software and videos for technical education, new computer-assisted drafting program.

Heathkit/Zenith Educational Systems
Hilltop Rd.
St. Joseph, MI 49085
(616) 982-3205

Electronic kits, programmed learning courses in electronics and computer technology, test and experiment hardware, robotics, and associated software.

Hewlett-Packard
1820 Embarcadero Rd.
Palo Alto, CA 94303
(415) 857-8000

Computer manufacturer; high resolution shaft encoder manufacturer.

Hi-Tek Sales/BNF
119 Foster Street
Peabody, MA 01961-3357
(617) 532-2323

Mail order surplus. Source for motors (stepper and otherwise), old computer parts, cables, connectors, switches, and miscellaneous items.

Hobar Publications
1234 Tiller Lane
St. Paul, MN 55112
(612) 633-3170

Instructional materials for Industrial Technology course, books, videos, microcomputer programs, slide-cassette programs, tools and safety materials.

Jameco Electronics
1355 Shoreway Rd.
Belmont, CA 94002
(415) 592-8097

Mail order. Components, PC-compatible boards and subsystems.

JDR Microdevices
1224 S. Bascom Ave.
San Jose, CA 95128
(418) 995-5430

Large selection of new components, wire-wrap supplies, PC-compatible boards and subsystems.

Jerryco, Inc.
601 Linden Place
Evanston, IL 60202
(312) 475-8440

Surplus mechanical and electronic gadgets for robots, science related materials; source for motors, rechargeable batteries, switches, selenoids, and more.

John Deere
Public Relations Dept.
Moline, IL 61265

Catalogs of slides and manual for servicing hydraulic and electrical systems.

KEITHLEY METRABYTE/ASYST/DAC
440 Myles Standish Blvd.
Taunton, MA 02780
(508) 880-3000

Catalogs, personal computer measurement and control products ranging from single board data acquisition, imaging, instrumentation and communication products.

Kelvin Electronics
Seven Fairchild Ave.
Plainview, NY 11803
(516) 349-7620

Electronic components, robotic kits, computer kits, bar-code systems, instruments and technology education supplies and tools

L. J. Technical Systems, Inc.
19 Power Drive
Hauppauge, NY 11788
(516) 234-2100

EMU automation package together with a range of electronics teaching systems, including unique workbooks written for technology education.

L.J. Technical Systems, Inc.
620 Springfield Ave.
Berkeley Heights, NJ 07922
(210) 464-5181

Technology education products including robots, CIM cells, communication trainers, fiber optics, microprocessors, sensors, and control systems.

Lab Volt Systems
Box 686
Farmingdale, NJ 07727
(800) 223-1057

Training systems of all types in hydraulics, pneumatics, electronics, motor controls, robotics, programmable controller, and power technology.

LEGO Education Division
555 Taylor Rd.
Enfield, CT 06082
(800) 243-4870, 527-8339
(203) 749-2291

LEGO models, interfaces to computers, mechanical kits, and LOGO programs.

Light Machines Corporation
669 E. Industrial Park Dr.
Manchester, NH 03103
(603) 625-8600

SpectraLIGHT Lathe/Mill system, CAD/CAM/CNC training system with robot interface capabilities that integrates with Apple and IBM.

Mark V Electronics
248 East Main Street, Suite 100
Alhambra, CA 91801
(818) 282-1196

Mail order. Kits for frequency counters, amplifiers, gadgets, and more.

Megatech Corporation
29 Cook Street
Billerica, MA 01866
(617) 273-1900

Energy, power and automotive technology, worldwide suppliers, including service capability, equipment set up, installation of heavy equipment and training of the end-user.

Mercury Marine
Division of Brunswick Corp.
Fond Du Lac, WI 54935

Outboard and marine service training aids for educational institutions.

Micro Switch
11 West Spring Street
Freeport, IL 61032
(815) 235-6600

Switch and pressure transducer manufacturer.

Microprocessors Unlimited, Inc.
24000 S. Peoria Ave.
Beggs, OK 74421
(918) 267-4961

Mail order. Integrated circuits (memory, EPROMs), etc.

Midwest Products Co., Inc.
400 S. Indiana St.
P.O. Box 564
Hobart, IN 46342
(212) 942-1134
(800) 348-3497
Fax: (219) 947-2347

Model airplane programs such as Delta Dart Model Airplane and a variety of technology education programs.

Modern School Supplies, Inc.
P.O. Box 958
Hartford, CT 06143
(203) 243-9565
(800) 243-2329

Drafting, art and graphic art supplies and equipment for occupational education and industrial technology.

Motorola Semiconductors
P.O. Box 20912
Phoenix, AZ 85036

IC manufacturer: motor control, remote control transmitter/receiver, microprocessor.

Mouser Electronics
National Circulation Center
P.O. Box 699
Mansfield, TX 76063
(800) 633-2246, 346-6873
Fax: (817) 483-0931

Catalogs, prototype kits, hardware/PC boards, fuses and holders, speakers/microphones, capacities equipment/tools/meters, capacitors, transformers, inductors, etc.

National Semiconductor
2900 Semiconductor Dr.
Santa Clara, CA 95051
(408) 721-5000

IC manufacturer; microprocessor, remote control IC's, D/A and A/D converters.

Omitron
770 Amsterdam Ave.
New York, NY 10025
(800) 223-0826

Variety of high quality electronic components, and equipment in various fields of technology.

PASCO Scientific
1876 Sabre St.
Hayward, CA 94545
(415) 786-2800

Laboratory equipment in physics, mechanics, energy-related, lasers, microwaves and optics.

Paxton/Patterson
5719 W. 65th St.
Chicago, IL 60638
(800) 323-8484

CAD/CAM packages operating on IBM or Apple IIe computer, safety and machine maintenance videos, full line of supplies and equipment.

PITSCO
P.O. Box 1328
Pittsburgh, KS 66762
(316) 231-0000
(800) 835-0686

Expanded line of technology education supplies covering computer graphics, robotics, lasers, radio-controlled models and software, new plastics division. Syringes and plastic tubing for hydraulics; plastic gears, wheels, etc.

Plessey Semiconductor
Plessey Solid State
3 Whatney
Irvine, CA 92714
(714) 951-5212

IC manufacturer; remote control chips.

Point Control Company
P.O. Box 2709
Eugene, OR 97402
(503) 344-4470

Integrated CAM system for automatic code generation for any CNC machine; graphic interface for easy interactive tool path specification; macros, 3-D, animated tool path verification.

R & D Electronic Supply
100 E. Orangethorpe Ave.
Anaheim, CA 92801
(714) 773-0240

Mail order. Power supplies, computer equipment, and test equipment.

Radio Shack
One Tandy Center
Fort Worth, TX 76102

Popular components and ICs. Carries general instrument SPO-256-A-L2 and general companion CST256-AL2 speech synthesis chip (3.12 MHz crystal special order), UM3482A melody generator, wire-wrapping supplies and tools, R/C toys, and walkie-talkies.

Rhino Robots, Inc.
308 S. State St.
P.O. Box 4010
Champaign, IL 61820
(217) 352-8485

Rhino Robotics XR-3 robotic revolute arm and SCARA arm and peripheral accessories. Rhino Robot's "Robo Talk" robotic language and courseware.

Robotmart
4720 Boca Raton Blvd. Suite 101
Boca Raton, FL 33431
(407) 394-3577

Mini FMS systems, smart CAM systems.

Safety Rules, Inc.
3727 Joan Drive
Waterloo, IA 50702
(800) 641-5466

Catalogs, safety signs and products for school and industry.

SATCO
924 S. Nineteenth Ave.
Minneapolis, MN 55404
(612) 370-2555

Wide range of supplies and equipment for the school shop.

SBC Mart
P.O. Box 1296
Ridgecrest, CA 93555
(619) 375-5744

Mail order. PC-compatible components and subsystems.

Scientific Labs, Inc.
P.O. Box 803788
Houston, TX 77280
(800) 654-9750

Principles of technology equipment, "Introduction to Technology" CAI software package by IBM.

Sharon Industries
693 Brokaw Rd.
San Jose, CA 95112
(408) 436-0455

Mail order and retail store. New and surplus electronic components, IC's, computers, PC-compatible boards and subsystems.

Signetics
811 East Arques Ave.
Sunnyvale, CA 94088
(408) 739-7700

IC manufacturer; stepper motor control chips, remote control chips.

Silconix
2201 Laurelwood Rd.
Santa Clara, CA 95054
(408) 998-8000

IC manufacturer; power MOSFET's.

Silicon Valley Surplus
4401 Oakport
Oakland, CA 94601
(415) 261-4506

Surplus electronic, computer, and robotic goodies.

Specialized Products Co.
313 Premier Drive
Irving, TX 75063

Service and repair computers and electronic equipment, installation, tools and equipment.

Stanley-Proto Industrial Tools
Division of Stanley Works
14117 Industrial Park Blvd.
Covington, GA 30209
(404) 787-3800

Hand tools including sockets, wrenches, tape rules, screwdrivers, leather and canvas products, hammers and miscellaneous others.

Stock Drive Products
55 S. Denton Ave.
New Hyde Park
New York, NY 11040
(516) 328-3300
TWX: (510) 223-0642

Gears, sprockets, chains, and more. Available through local distributor. Catalog and engineering guide available.

Sub Logic Corp.
713 Edgebrook Drive
Champaign, IL 61820
(217) 359-8442

Software, catalogs, tools and equipment in communications, transportation, energy and power, and other areas of technology.

Superior Electric Co.
383 Middle Street
Briston, CT 06010
(203) 582-9561

Stepper motor manufacturer.

Synergistic Technology Systems
P.O. Box 1707
917 E. Jefferson Street
Pittsburgh, KS 66762
(800) 828-5787
(316) 231-1333
Fax: (316) 231-3257

Offers technology items such as software, computers, and over 16 synergistic technology modules in electricity, electronics, applied physics, communications and other areas; uses 39 different computer programs and numerous hands-on activities.

Technovate, Inc.
910 SW Twelfth Ave.
Pompano Beach, FL 33069
(305) 946-4470

Computer integrated manufacturing (CIM), material strength, fluid mechanics, heat transfer and equipment for most disciplines.

Tektron Equipment Corporation
530 Grand Island Blvd.
Tonawanda, NY 14150
(716) 832-8953

Printed circuit boards and processing equipment and supplies, instructional packages, technical advice and support.

Texas Instruments
Box 5012
Dallas, TX 65265
(214) 995-3821

IC manufacturer; speech chips, microprocessors.

The L.S. Starrett Company
121 Crescent St.
Athol, MA 01331
(617) 249-3551

Precision tools, micrometers, verniers, dial gauges, electronic gauges, surface plates, vises and educational videos.

The Parke System
805 S. Devonshire
Springfield, MO 65802
(417) 883-0427

Very affordable technology education & process equipment and support teaching materials.

The Science Instruments Company
6122 Reisterstown Rd.
Baltimore, MD 21215
(301) 358-7810

High technology laboratory panels, simulators, and electronics & physics training equipment.

Theta Industrial Products
Box 70AB-FL8
Mound, MN 55364-0700

Catalogs, teaching programs for safety, teaching activity modules and tools, and materials & equipment.

TII Robotic Systems
631 S. Vermont St.
Palatine, IL 60067
(312) 991-2636

Training systems, hardware and software for fluid power, robotics, controls and maintenance; from fundamentals to advanced technology.

Transcat
Box D-1
Rochester, NY 14606
(800) 828-1470
Fax: (716) 458-0543

Energy industry and process, test measurement and calibration instruments. Also provides repairs of all types of instruments.

Transtech Systems
Division of Creative Learning Systems, Inc.
9899 Hibert St., Suite C
San Diego, CA 92131
(619) 566-2880
(800) 458-2880

Technology Lab 2000, integrated equipment and courseware for a computerized lab, transformable to meet the demands of evolving programs in future-oriented technology education. Also reference books, software, fishertechnik, Meccano and other technology education supplies.

Unilab , Inc.
9102 Industry Drive
P.O. Box 837
Unit I
Manassas Park, VA 22111
(703) 330-1997

Contemporary electronics, control systems, MEA microelectronics for all (problem-solving), Alpha prototype kits and supplies, micro-technology resources, POLYMEK and mechanical construction components.

United Products, Inc.
1123 Valley
Seattle, WA 98109
(206) 682-5025

Fishertechnik robot kits.

Valley Computers
613 N. Idlewild
Kaukauna, WI 54130
(414) 766-3589

Mail order. Stepper motors, computer components, and test equipment.

Vishay Engineering
63 Lincoln Highway
Malvern, PA 19355
(215) 644-1300

Supply different types of resistors, and strain gauge materials.

Whitewings Paper Airplanes
Mr. Nelson Goodsell
Sales Manager
AG Industries, Inc.
1411 4th Avenue, Suite 727
Seattle, WA 98101
(206) 447-1824

Paper airplane models

Windsor Distributors
19 Freeman St.
Newark, NJ 07105
(800) 645-9060

Mail order. Surplus electronics.

Part 7: Associations/Organizations

Aerospace Educational Foundation
1501 Lee Hwy.
Arlington, VA 22209
(703) 247-5800

Aerospace Youth Council
1785 Massachusetts Ave., NW
Washington, DC 20006

Air Transport Association
Attn: Mr. W.G. Osmun
Public Relations Department
1709 New York Ave., NW
Washington, DC 20006

Alternative Energy Resources Organization
44 N. Last Chance Gulch, #8 & #9
Helena, MT 59601
(406) 443-7272

American Association for the
Advancement of Science
Committee on Opportunities in Science
1515 Massachusetts Ave., NW
Washington, DC 20005
(202) 326-6400

American Association of Community and
Junior Colleges
Suite 410
One DuPont Circle, NW
Washington, DC 20036

American Automobile Association
8111 Gatehouse Road
Falls Church, VA 22047
(703) 222-60000

American Coal Foundation (ACF)
National Coal Association
1130 17th St, NW, Suite 220
Washington, DC 20036
(202) 466-8630

American Council for an Energy
Efficient Economy
1001 Connecticut Ave., NW, Suite 535
Washington, DC 20036
(202) 429-8873

American Electronics Association
5201 Great American Pkwy, Suite 520
Santa Clara, CA 95054
(408) 987-4200

American Gas Association (AGA)
1515 Wilson Blvd.
Arlington, VA 22209
(703) 841-8400
Telex: 83-4763

American Industrial Hygiene Association
475 Wolf Ledges Parkway
Akron, OH 44311
(216) 762-7294

American Institute of Aeronautics and
Astronautics
1290 Avenue of the Americas
New York, NY 10104

American Institute of Chemical Engineers
345 East 47th Street
New York, NY 10017

American Institute of Industrial Engineers
25 Technology Park
Atlanta, Norcross, GA 30092

American Institute of Physics, Inc.
335 E. 45th Street
New York, NY 10017

American Mathematical Society
P.O. Box 6248
Providence, RI 02940

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10013
(212) 354-3300

American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525
(312) 352-6611

American Petroleum Institute
Information Service Department
2101 L Street, NW
Washington, DC 20006

American Public Power Association
2301 M Street, NW, Suite 300
Washington, DC 20037
(202) 775-8300

American Society for Engineering Education
One DuPont Circle, NW
Suite 400
Washington, DC 20036

American Society for Quality Control, Inc.
230 W. Wells
Milwaukee, WI 53203

American Society of Heating and Air Conditioning
1791 Tullie Circle, N.E.
Atlanta, GA 30329
(404) 636-8400

American Society of Safety Engineers
1800 East Oakton Street
Des Plaines, IL 60018
(312) 692-4121

American Solar Energy Association
c/o John Lillard
1667 K. St., NW, Suite 395
Washington, DC 20006
(202) 347-3920

American Solar Energy Society
2400 Central Ave., B-1
Boulder, CO 80301
(303) 443-3130

American Trucking Association
Education Services
Public Relations Department
1616 P. Street, NW
Washington, DC 20036

American Vocational Association (AVA)
828 South 2nd Street, Rm 403
Springfield, IL 62704
(217) 433-0815

American Wind Energy Association
1730 N. Lynn #610
Arlington, VA 22209
(703) 276-8334
Fax: (703) 527-2833

Association of American Railroads
Office of Information and Public Affairs
1920 L Street, NW
Washington, DC 20036

Association of Energy Engineers
4025 Pleasantdale Rd., Suite 420
Atlanta, GA 30340
(404) 447-5083

Association of General Contractors of Missouri
P.O. Box 94
Jefferson City, MO 65102
(314) 636-3188

Atomic Industrial Forum
Public Relations Dept.
7101 Wisconsin Ave.
Bethesda, MD 20014

Aviation Distributors and Manufacturers Association
1900 Arch Street
Philadelphia, PA 19103

Commercial Refrigerator Manufacturers Association (Heating and Cooling)
1101 Connecticut Avenue, NW
Washington, DC 20036
(202) 857-1145

Council of Supervisors:
International Technology Education Association (ITEA)
c/o William Kabakjian, Jr.
John F. Kennedy Center
734 Schuylkill Avenue
Philadelphia, PA 19146
(215) 875-3800

Electric Auto Association
1249 Lane Street
Belmont, CA 94002
(415) 591-6698

Electric Industries Association
2001 1st. St., NW
Washington, DC 20006
(202) 457-4900

Electrical Generating Systems Association
P.O. Box 9257
Coral Spring, FL 33065
(305) 755-2677

Energy Consumers and Producers Association
P.O. Box 1726
Seminole, OK 74868

Energy Educators Association
Box 20, Bridges Hall 160A
Moorhead State University
Moorhead, MN 56563

Energy Telecommunication and
Electrical Association
P.O. Box 795038
Dallas, TX 75379
(214) 578-1900

Engineers' Council for Professional
Development
345 E. 47th Street
New York, NY 10017

Environmentalists for Full Employment
1101 Vermont Ave., NW, #305
Washington, DC 20005

Hydraulic Institute
712 Lakewood Center, N.
14600 Detroit Ave.
Cleveland, OH 44107
(216) 226-7700

Illuminating Engineering Society of North
America
345 East 47th Street
New York, NY 10017
(717) 783-8506

Industrial Safety Equipment Association, Inc.
1901 North Monroe Street
Arlington, VA 22210
(703) 525-1695

Institute of Electrical & Electronics Engineers
345 E. 47th St.
New York, NY 10017
(212) 705-7900

Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

Institute of Nuclear Materials Management
2400 East Devon Avenue
Des Plaines, IL 60018

International Brotherhood of Electrical Workers
1125 15th Street, NW
Washington, DC 20005

International Nuclear and
Energy Association
645 N. Michigan Ave., Suite 860
Chicago, IL 60611
(312) 642-9502

International Solar Energy Society
American Section
12441 Parklawn Dr.
Rockville, MD 20852

International Technology Education
Association (ITEA)
1914 Association Drive
Reston, VA 22091-1502
(703) 860-2100

Missouri Industrial Technology Education
Association (MITEA)
c/o Steve Coffman
P.O. Box 480
Jefferson City, MO 65102
(314) 751-7764

Missouri Vocational Association (MVA)
101 Madison, Fourth Floor
Jefferson City, MO 65101
(314) 634-7366

Motor Vehicle Manufacturers Association
of the U.S., Inc.
300 New Center Bldg.
Detroit, MI 48202

America runs on wheels, know how - what it takes to make your car, saving energy, trucks and buses serve America, your way to better fuel economy and lifelines - how trucks serve America.

National Aeronautic Association
806 15th Street, NW
Room 610
Washington, DC 20005

National Association for Science, Technology
and Society
128 Willard Building
University Park, PA 16802
(814) 865-9951

National Association for the Exchange of
Industrial Resources (NAEIR)
Department IM
560 McClure St.
P.O. Box 8076
Galesburg, IL 61402
(309) 343-0701

National Association of Power Engineers
2350 E. Devon Ave., Suite 115
Des Plaines, IL 60018
(312) 298-0600

National Association of Rocketry
182 Madison Drive
Elizabeth, PA 15037

National Electrical Manufacturing Association
2101 L. St., NW
Washington, DC 20037
(202) 457-8400

National Energy Resources Organization
11529 Montgomery Rd.
Beltville, MD 20705
(301) 937-2799

National Fire Protection Association
Batterymarch Park
Quincy, MA 02269
(617) 770-3000

National Institute of Occupational Safety & Health
Division of Training and Manpower
Curriculum Development Branch
4676 Columbia Parkway
Cincinnati, OH 45226
(513) 533-8256

National LP-Gas Association
1800 North Kant Street, Suite 1004
Arlington, CA 22209

National Rural Electric Cooperative Association
1800 Massachusetts Avenue, NW
Washington, DC 20036

National Science Foundation
1800 G Street, NW
Washington, DC 20550

National Science Teachers Association
1724 Connecticut Ave., NW
Washington, DC 20036

Oak Ridge Associated Universities (ORAU)
P.O. Box 117
Oak Ridge, TN 37830

Power Electronics Society
c/o Institute of Electrical and
Electronics Engineers
345 E. 47th St.
New York, NY 10017
(212) 705-7867

Power Tool Institute
501 West Algonquin Road
Arlington Heights, IL 60005
(312) 593-8350

Radiation Research Society
925 Chestnut Street
Philadelphia, PA 19107

Sierra Club
730 Polk Street
San Francisco, CA 94109

Solar Energy Industries Association
1730 North Lynn Street, Suite 610
Arlington, VA 22209-2009
(703) 524-6100

Technology Education Division
American Vocational Association (AVA)
1410 King Street
Alexandria, VA 22314
(703) 683-3111

Technology Student Association
1908 Association Dr.
Reston, VA 22091
(703) 860-9000

The Electronic Data Interchange Association
1101 17th St., NW, Suite 712
Washington, DC 20036
(202) 293-5514

Thomas Alva Edison Foundation
Cambridge Office Plaza, Suite 143
18280 W. Ten Mile Road
Southfield, MI 48075

U.S. Energy Association
1620 1st St., Suite 615
Washington, DC 20006
(202) 331-0415

Union of Concerned Scientists
26 Church Street
Cambridge, MA 02238

Part 8: Software

Advanced Microsystems Technology
P.O. Box 1942
Bowling Green, KY 42102
(502) 782-1888

Software program modules focusing on electrical symbols, components, introduction color codes, circuits, resistance etc.

Broderbund
17 Paul Drive
San Rafael, CA 94903-2101
(800) 521-6263
(415) 492-3200

Variety of software for Apple, Macintosh and IBM pc computers.

Budgetbytes
1647 SW 41st Street
Topeka, KS 66609
(800) 356-3551

Large selection of public domain and shareware software.

Optimum Resource Software Incorporated
10 Station Place
Norfolk, CT 06058
(800) 327-1473
(203) 638-2400
Fax: (203) 542-5685

Car Builder, and a variety of public domain children's educational software and various programs in areas such as math skills, printers, cables and graphs, electric car builder, ABC and others.

CNC Software, Inc.
7212 S. Wapato St.
Tacoma, WA 98409
(206) 474-1850

Software for IBM pc computers.

Computer Applications Tomorrow
P.O. Box 4093
Carlsbad, CA 92008

ROBCAT

Creative Learning Systems, Inc.
9899 Hibert, Suite C
San Diego, CA 92131
(800) 458-2880
(619) 566-2897

Software for Apple IIe, Macintosh & IBM pc computers.

Dynacomp, Inc.
The Dynacomp Office Bldg.
Catalog Dept.
178 Phillips Road
Webster, NY 14580
(800) 828-6772
(716) 265-4040

Various kinds of software for Apple, IBM pc, Macintosh and other computers.

Educorp
531 Stevens Ave. #B
Solana Beach, CA 92075

Public domain, software and accessories for Macintosh computers.

Sub Logic Corporation
713 Edgebrook Drive
Champaign, IL 61820
(217) 359-8482

Flight Simulator II

Hearlihy and Company
714 W. Columbia Street
P.O. Box 869
Springfield, OH 45501

Robot Assembly Lab

Heizer Software
1941 Oak Park Blvd., Suite 30
P.O. Box 232019
Pleasant Hill, CA 94523

Catalogs, disks and various programs for IBM pc, and Apple's hypercard.

Human Relations Media
175 Tompkins Avenue
Pleasantville, NY 10570-9973

GLIDE PATH

Illinois Vocational Curriculum Center
Sangamon State University, F-2
Springfield, IL 62794-9243
(217) 786-6375
(800) 252-IVCC

A variety of trade- and industrial-related Apple software.

In Cider
P.O. Box 8987
Boulder, CO 80328-8987
(800) 831-2694
(318) 221-8718

Variety of Apple II software that has direct application to ITE.

K-12 Micromedia Publishing
P.O. Box 677
6 Arrow Road
Ramsey, NJ 07446
(201) 825-8888

Appleworks organizer, software organizer, Microsoft works, IEP works, school works: teacher, site license included for most titles, accessories and enhancement for educators.

Kelvin Electronics
7 Fairchild Avenue
Plainview, NY 11803
(800) 645-9212
(516) 349-7620
Fax: (516) 349-7830

Public domain and commercial software for Apple II and IBM pc computers.

Kitchen Sink Software
903 Knebworth Court
Westerville, OH 43801
(614) 891-2111

Technology software for Apple IIe.

MECC
3490 Lexington Avenue North
St. Paul, MN 55126
(612) 431-3500

Mesa Research, Inc.
Rt. 1, Box 1456A
Waco, TX 76710

CONSTRUCTION ESTIMATOR

Midwest Software
111 North 56th, Suite 206
Lincoln, NE 68504
(800) 322-9607
(402) 466-3588
Fax: (402) 466-3865

Software programs for IBM and compatible computers.

National Association for Science, Technology, & Society (NASTS)
117 Willard Building
University Park, PA 16802
(814) 865-9951
Fax: (814) 865-3047

National Instruments
12109 Technology Blvd.
Austin, TX 78727-6204
(512) 250-9119
Fax: (512) 250-0382
Telex: 756737 NAT INST AUS 800-IEEE-488

Provides top-quality software such as Labwindows and Labview.

National Public Domain Software Center
1533 Avohill Street
Vista, CA 92084
(619) 727-1015

National Software Lending Library
507 Race Street
Cambridge, MD 21613
(301) 221-0551

NIMCO
National Innovative Media
Route 2, Box 301B
Calhoun, KY 42327
(800) 962-6662
(502) 273-5050
Fax: (502) 273-5844

Competency-based software, air conditioning/refrigeration software, appliance repair software, vocational instructional software in electronics, electricity, autobody repair, auto mechanics,etc.

Online Technology
4210 Minor Hill Road
Ashland, MO 65010
(314) 657-1810

Curriculum materials for the historical development of technology and impact on society. Also, materials for information projects using the Apple II, IBM, and Macintosh computers.

PC-SIG
1030 East Duane Street, Suite D
Sunnyvale, CA 94086
(408) 730-9291

Point Control Co.
1750 Willow Creek Circle
P.O. Box 2709
Eugene, OR 97402
(503) 344-4470
Fax: (503) 342-8277

CAM software for IBM pc.

Public Brand Software
P.O. Box 51315
Indianapolis, IN 46251
(800) 426-3475

Wide range of public domain IBM pc or compatible software. Many with direct application to ITE.

Public Domain, Inc.
5025 South Rangeline Road
West Milton, OH 45383
(513) 698-5638

Offers a complete source of public domain and software for Apple II and Macintosh computers. Also collects individual programs from authors and other sources around the world and compiles these on disks.

Queue, Inc.
338 Commerce Dr.
Fairfield, CT 06430
(800) 232-2224
(203) 335-0908
Fax: (203) 336-2481

A great deal of software in all public domain areas and programs in science, laboratory, heat, temperature, motion and sound, English, foreign language, literature and other areas.

Reasonable Solutions
2101 West Main Street
Medford, OR 97501
(800) 876-3475
(503) 776-5777
Fax: (503) 773-7803

Software for IBM pc's & Macintosh with direct application to ITE, service and support.

Shopware Educational Systems
Department K-2
Rt. 1, Box 330-E
Aberdeen, WA 98520-9984
(206) 532-3392
Fax: (206) 533-5172

Various types of computer software for vocational-technical education such as Apple II, IBM pc & Macintosh.

SOFTSWAP
Computer Using Educators
P.O. Box 217104
Concord, CA 94527
(415) 685-7265

Variety of public domain Apple IIe and IBM pc computers.

Software Exchange
Oakland Schools
2100 Pontiac Lake Road
Pontiac, MI 48054
(313) 858-2019

Software Library
Mail Order Department
North Central Regional Library
238 Old Station Road
Wenatchee, WA 98801
(509) 663-1117

Software Technologies, Inc.
100 Corporate Woods
Rochester, NY 14623
(800) 348-0033
(716) 272-0070

Provides software for maximum productivity in pc-based data acquisition and control.

State of Iowa
Department of Public Instruction
Career Education Division
Grimes State Office Building
Des Moines, IA 50319

Public domain Apple IIe and IBM pc software, many with direct application to ITE.

Sunburst Communications
39 Washington Ave.
Pleasantville, NY 10570

GEARS; STRATEGIES IN PROBLEM-SOLVING, PROFESSIONAL SIGN MAKER-THE FACTORY, and other educational software from kindergarten to 12th grade, including other fields of technology.

Technology Education Software Bank
International Technology Education
Association (ITEA)
Ohio State University
190 West 19th Street
Columbus, OH 43210
(614) 422-7471

Variety of industrial technology education software for educators and students.

The Big Red Apple Club
1105 South 13th Street
Norfolk, NE 68701

Various kinds of public domain compatible software. Most of them with direct application to ITE.

The Learning Company
545 Middlefield Road, Suite 170
Menlo Park, CA 94025

ROBOT ODYSSEY and a variety of children's educational software and programs such as language arts, problem solving, mathematics and other subjects, ranging from pre-school to high school.

The Public Domain Exchange
2074C Walsh Avenue, Dept. 707
Santa Clara, CA 95050
(800) 331-8125
(408) 496-0624, 6439

Variety of quality Apple II software with direct application to ITE; catalog.

The Teacher's Laboratory, Inc.
P.O. Box 6480
214 Main Street
Brattleboro, VT 05301

ROBOTICS KIT, and a variety of equipment and resource textbooks on subjects such as measurement, computers, robotics, simple machines, math resources, electricity and electronics.

Vernier Software
2920 SW 89th Street
Portland, OR 97225
(503) 297-5317
Fax: (503) 29701760

Software instructions & hardware for IBM pc, Apple II and multipurpose laboratory interface.

Public domain user groups:

- Apple User Group Connection
  20525 Mariani Avenue (M536-AA)
  Cupertino, CA 95014
  (800) 538-9696 Ext. 500

- Boonslick Apple Users Delegation
  P.O. Box 824
  Columbia, MO 65205
  Jon Graymack
  (314) 442-6039

- State Macintosh User Group
  c/o MO Department H
  1738 East Elm Street, P.O. Box 570
  Jefferson City, MO 65101
  (314) 751-6002

- MUse, P.O. Box 811
  Columbia, MO 65205
  (314) 445-4496, 874-8657

- Sedalia Apple User Group
  2316 W. 5th Street
  Sedalia, MO 65301
  (816) 827-2623

- Ros Lauck User Group
  1903 E. 36th
  Joplin, MO 64801
  (417) 781-6433

- Tomas R. Piper
  Apple Jac Mac User Group
  2539 Lexington Drive
  Jefferson City, MO 65101
  (314) 634-3102

There is a great deal of public domain software available to help both teachers and students in their programs for application in energy and power technology courses. Technology Education Software Bank has the following programs in disk form for your use with both Macintosh and Apple IIs.

1. Antivirus
2. Clip Art
3. Communication
4. Desk Accessories
5. Education
6. Hypercard Stacks
7. Each technological system
8. Programming and utilities
9. System Utilities
10. Electronics
11. Teaching Aids

A variety of programs are available to help educators in energy and power. A sampling of these include: we urge teachers to try these and others.

Apple Works:
The newest version of Appleworks programs for word processing, database, and spreadsheet capabilities on the IIe and GS. Contains a good spell checker.

Adelphian Grade Book:
This package can handle up to 9 classes, 40 students per class, and 50 assignments per grading period. Entries may be edited and the package is menu-driven. This is an excellent starter package for those who are not computer experts. (Kitchen Sink).

Caddraw System:
This package has been recommended in several publications including "Cad Educator", "School Shop" and "Industrial Education". The consensus is that for the IIe Caddraw is an effective design package. The package consists of three segments that may be purchased separately. Caddraw may be enhanced by the purchase of symbols libraries that contain symbols ready to place on the drawing. Libraries of predrawn projects are available in several areas of IA&T. (Kitchen Sink).

CNC Trainer:
CNC Trainer will simulate and drive CNC vertical milling machines. It is easy enough for middle school students to use. Editing is possible using familiar Appleworks commands; it has a built in syntax checker; and shows a simulation on the screen. It uses metric, english, or a combination of these measures, and it can specify up to 24 tools per program. Drivers are available for Bridgeport and Dyna milling machines.

Iowa Disk #3:
Program #A040 Trouble-Shooting, Thompson. This program follows a testing format that presents the student with information in table format before each test section. The program sends the learner back to the information section when questions are missed.

International Technology Education Assn. (ITEA)
1914 Association Drive
Reston, VA 22091-1502
(703) 860-2100

ITEA Disk # 212:
Program #A 015 Power exam is a test over power sources including turbine engines and generally covers: 1. People who invented different engines; 2. 4 & 2 stroke gasoline basic operating principles; 3. 2 stroke diesel basic operating principles; 4. Sterling engine basics operating principles; 5. Gas turbine basic operating principles.

ITEA Disk #212:
Program #I 015 Engine. Graphically demonstrates the strokes of a four cycle engine.

ITEA Disk #212:
Program #A 011 Machine Speed Calculations. This program calculates power tool speeds and pulley sizes. This program will accept any of the known information and will produce the information unknown about a system of pulleys, drivers, and machines.

ITEA Disk #101:
All programs on this disk deal with management of the instruction process; grade book; test making and attendance.

ITEA Disk #21:
Program "Air Foil" draws wing sections based on the camber, position of maximum camber, and maximum thickness; all as a percent of the chord.

ITEA Disk #210:
Program #A007 converts metric measurements to English values.

ITEA Disk # 209:
This disk lists the following eight programs which deal with energy and power:

1. Assault vehicle speed
2. Engine (test drill)
3. Sun's rays
4. Ohm's law
5. Ohm's-Watt's law
6. Risistor color decoding
7. Basic electricity(test drill)
8. Basic electricity test

Energy & Power Technology Master Disk Documentation

The disk contained with this guide represents a sampling of the public domain materials available to technology education instructors. Please note that its files are compressed to maximize the number of programs available on one disk. To use any of the programs first uncompress the disk by booting it on an enhanced Apple IIe. To do this you will need the E&P Guide 1990 Master Disk and three blank 5-1/4" disks. This process will work best on a two drive machine. You will only need to do this once because it generate three PRO DOS working disks that will run on most of the Apple II series.

Energy and Power Technology Guide 1990 Program
Master Disk Unshrinking Instructions

To run the software, the following equipment is needed.

1. Apple II*e* [enhanced], IIc, or IIgs
2. Monitor (monochrome or color)
3. Two 5-1/4" disc drives
4. Two write protect tabs
5. Appropriate cables
6. Three blank 5-1/4" floppy discs
7. The Energy and Power Master disc supplied with the guide.

Getting Started
Unshrinking/Extracting Files

To provide the teachers with as many programs as possible, whole discs have been shrunk in size. **These programs cannot be used until they have been unshrunk/extracted out of their smaller size**. This shrinking (compression) programs is very useful for archiving seldom used files or backup files. After a file or disc is shrunk, it can be moved around to floppies or hard drives. The compression program supplied with this guide is called Shrinkit. This is a public domain utility program written by Andrew E. Nicholas. (Thanks)

1. To unshrink/extract the information on the Energy and Power Master disc, place write protect tabs on both notches of this disc and place it into drive one. Turn on the computer.

2. Using the left or right arrow key, move the highlight bar over the word "U-Unshrink/Extract" and press return. Note: if you see a message calling for a 65C02 the computer you are using is not an enhanced IIe. You will need to get access to one to do the unshrinking. However, once you have unshrunk the disk, most of the programs should work on unenhanced IIe's and perhaps even II+ computers.

3. If everything is working, on the screen, a menu titled "Unshrink From File"will appear. Read this menu to find the file labelled Part Three.SHK.

4. Using the left or right arrow key, move the highlight bar over the word Part 3.

5. Place a blank disc into drive number 2.

6. Press the space bar to select the file "Part three" and a check mark will appear to the left of the highlight bar.

7. Press the return key and a menu showing the title of the file you've selected will appear. Confirm this by pressing the space bar if it is correct or else press the escape key. An arrow will now show to the left of the highlighted name.

8. Press the return key and a menu listing the possible destination drives will come up. Use the left or right arrow key to select S6,D2 140K DRIVE by moving the highlight bar over it. Press the return key to confirm your choice.

9. The light on drive number two will on and the screen will show the progress of the unshrinking. When the program is finished it will beep and a box with the word ok will come up. Press the return key and the program is back to the main menu with U-Unshrink/Extract highlighted.

10. Now take the Energy and Power Master disc (in drive 1), remove it, turn it over, and reinsert in drive 1. There are two more files on this new side to be extracted. They are titled Part 2 and Part 1.

11. Repeat steps 2 through 9 for these two files.

When the unshrinking process is complete, you will have three discs of public domain software, including one shareware program, related to Energy and Power. The new unshrunk discs contain the following.

Part 1 - The disc contain a host of public domain programs. Most of these were written in basic by instructors or novice programmers. Some of the programs are user friendly and others are less. The program disc is designed to let the user select and run a program by using the left or right arrow keys to select the program similar to the Shrinkit program. Other function keys are listed on the screen. For most of these program, if you want to quit in the middle of them, you will need to do a warm reboot (simultaneous pressing of the control, reset, and open apple keys).

Part 2 - This disc is a tutorial on engine theory with graphics. When this disc is booted, wait for the program to go through a series of credit screens. When it reaches the screen asking whether to show a 2-stroke motor or 4-stroke, type 1 and press return. Then follow instructions.

Part 3 - This disk is a program called Sunraycer. This program will let you design and build you own solar powered race car and test drive it.

Further documentation is provide as Appleworks word processing file located on side one of the Energy and Power disc. A complete listing of programs and a short description are included.

Disclaimer: These programs are provided as a service to the profession. The University of Missouri-Columbia, the Missouri Department of Elementary and Secondary Education, The Instructional Materials Laboratory and the project staff are not responsible for any problems that might arise from their use. The program authors have entered them into the public domain in the same spirit. Shareware programs must be acknowledged and paid for as per the instructions that display when they are run. If you choose not to keep a shareware program it should be deleted from the disk.

Part 9: Revision Form

Missouri Introduction to Energy & Power Technology Guide

To maintain the value of this Introduction to E & P Technology Guide, members of the profession are encouraged to submit suggestions for additions, revisions and other modifications of any part of this document.

Section #: ________ Section Name: ____

Part #________ Part Name: ____

My suggestion is a: ___ Revision ____ Addition ____ Other: ______________

My suggestion is to: (Attach pages and information as needed)

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